UNHAPPY AT YOUR OFFICE? HERE'S WHY *page 30*

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September/October 2010
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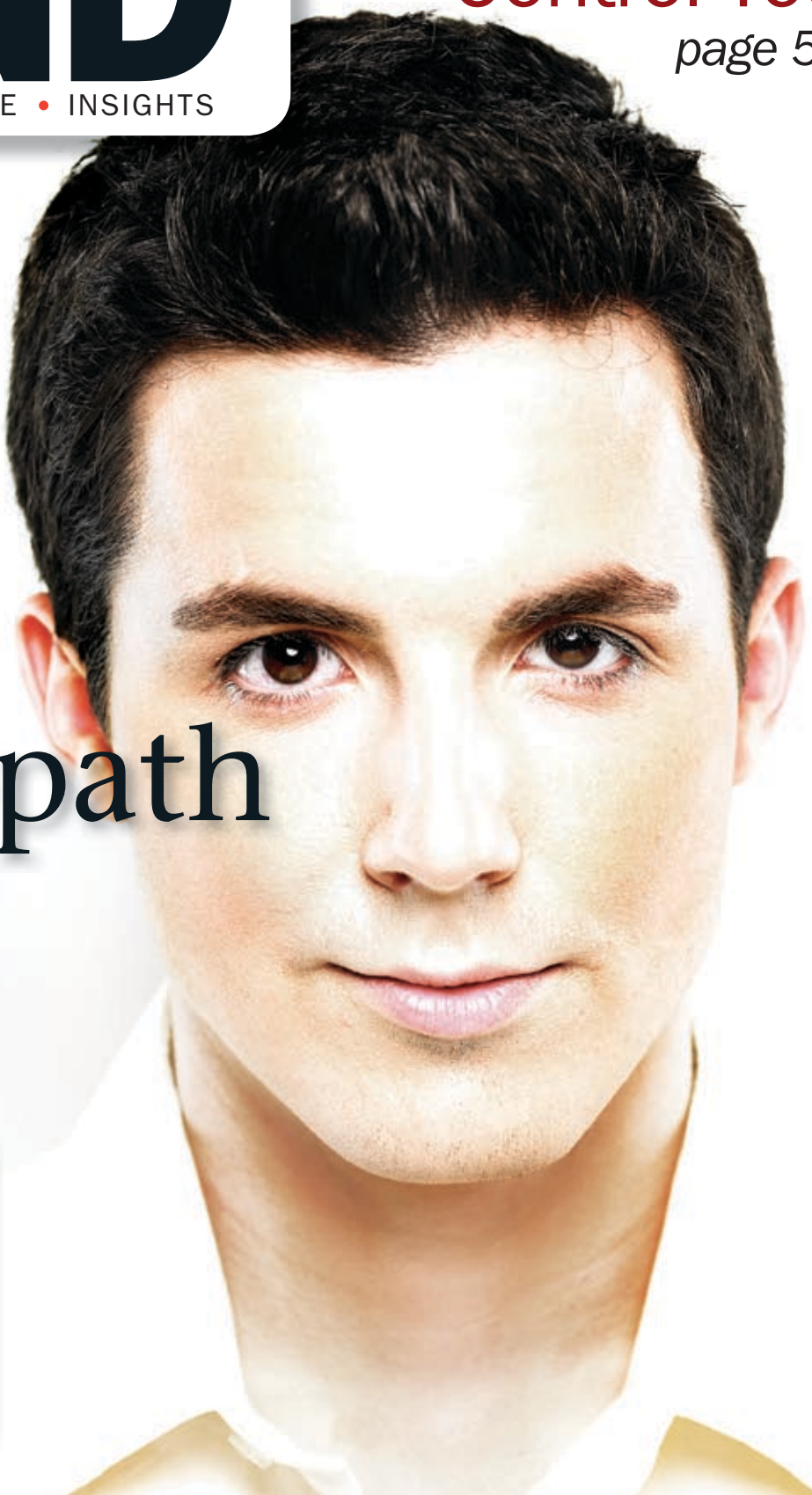
BRAIN CODE

Genes That Control You

page 56



The Making of a Psychopath

Why They Don't Care: They Can't

page 22

EDUCATION SPECIAL

Brainpower Boost

How Action Fuels Learning

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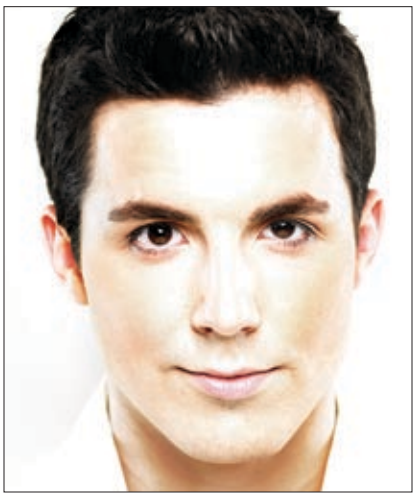
COVER IMAGE BY AARON GOODMAN



Head Spaces

"Does 'accommodate' have one 'm' or two?" asked an editor in our open workspace. Almost before I could say "two," the boss flew at us from her office. "Why aren't you working?" she demanded. She seemed mollified by my explanation. She stalked back to her office chair, periodically watching us through the glass window in the wall.

None of us focused too well for a while after that. But her whipsaw behavior was only part of the reason. As I now know—and as you will learn from "Cubicle, Sweet Cubicle," by sociologists S. Alexander Haslam and Craig Knight—the workspace itself already had done most of the productivity damage. We could not put what we wanted atop our desks, lest we ruin the cohesive look. The seating was changed without discussion. The lack of control over our situation interfered with our concentration. It's not difficult, however, to create better workspaces. Turn to page 30 to learn how.

We can adjust a physical environment to foster emotional well-being. But what happens when a person lacks emotion? The disturbing consequence: psychopaths, whose behavior ranges in severity from self-interested opportunists to remorseless killers; they may constitute 15 to 35 percent of prisoners in the U.S. They can charm by portraying emotion and empathy, yet they do not experience such feelings, write neuroscientists Kent A. Kiehl and Joshua W. Buckholtz in our cover story, "Inside the Mind of a Psychopath," starting on page 22. Because of a brain abnormality, they have, in effect, a learning disability that impairs emotional development. A new understanding of the mechanisms behind psychopathy ultimately could lead to treatments, perhaps including medicines and effective behavioral therapies.

Another kind of understanding—about how children learn—has the power to enhance cognition in young minds. In our special report, we explore how physical actions influence how kids think. Touch, for instance, is essential to learning. Gestures can help make abstract ideas concrete. And exercise boosts brainpower. In this back-to-school season, proceed to page 36 for an educational experience.

Mariette DiChristina
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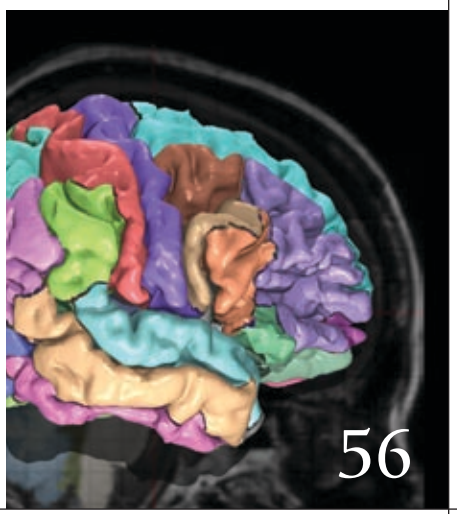
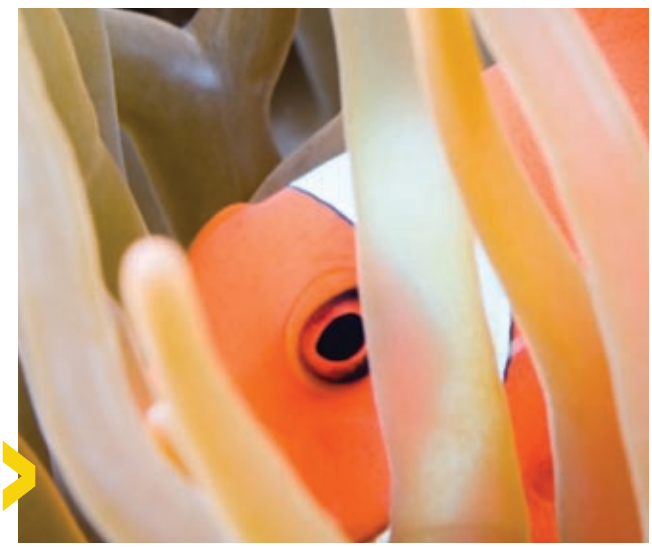
SCIENTIFIC AMERICAN MIND
Volume 21, Number 4, September/October 2010



FEATURES

DEPARTMENTS



Scientific American Mind (ISSN 1555-2284), Volume 21, Number 4, September/October 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.

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GENDER TALK

As a gender studies scholar, I was quite interested in your special issue. I read all the articles with great enthusiasm. I was, however, surprised that you featured only Deborah Tannen's ideas concerning gendered speech styles ("He Said, She Said"). Because there is so much fascinating research in the area, I was disappointed that she lists her own work exclusively as possible Further Reading. For other work in the field, visit the International Gender and Language Association (IGALA) Web site: www.lancs.ac.uk/fass/organisations/igala/Index.html.

Well done on a fascinating issue overall.

Allyson Jule
Trinity Western University
Langley, B.C.

PRAISE FOR MODERATION

"The Truth about Boys and Girls," by Lise Eliot, is the clearest and most unbiased psych article I have read in a long time. Far too many of these studies have interesting results, but then the authors make unwarranted leaps in the conclusions. I like that this one discussed the many possible causes of what we are seeing.

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

SELF-ATTRACTION

"The Third Gender," by Jesse Bering, is not of the quality I have come to expect from *Scientific American Mind*. The author reports myths as facts with no documentation, and the one theory he does document, Ray Blanchard's theory of autogynephilia, is perhaps the most controversial in the transsexual community. Sexual orientation is no more a part of our identity than it is a part of the average person's. Our condition centers around the internal subjective feeling of being the opposite gender to that assigned at birth.

Numerous studies support the belief that there is a biological genesis to these feelings. Your article has done nothing but further the view that transgendered people are freaks, rather than taking the opportunity to educate the public and fight the negative stereotypes.

I am disappointed that *Scientific American Mind* would publish such a poorly researched article that so poorly describes us and our condition.

Emily
San Diego

Here they go again.... As shown by the angry comments online, the antiautogynephilia folks have not stopped demonizing scientists who suggest that arousal by the idea of oneself as female explains some male-to-female (MtF) transsexualism—a theory supported by objective physiological evidence.

Why do some people get so angry about a theory they disagree with? Somehow they link it to violence, as if criminals who attack minorities pay attention to sexologists. Maybe they think it is shameful (I do not, and no one should). Maybe they are wounded and disordered to the point that they insist on everyone viewing and understanding them in the way they themselves do, and they act out with rage when anyone wonders if the theory might explain some transsexualism. It must be something beyond simply not resonating with their own experiences of their transitions and identities.

I would welcome the day when autogynephilia is disproved, partly because

knowledge will be advanced. But also partly because the shrill suppressors of sex science will move on. To that end, I would ask them to help advance science instead of terrorizing people they disagree with. How? Why not help fund, design and participate in studies of MtFs, including studies of arousal?

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

Are some men aroused by the thought of themselves as female?

THE SCIENCE OF LOVE

Harriet Hall's e-mail in Letters, in which she accuses Robert Epstein's "Love-Building Exercises" of not being scientific, shows a misunderstanding of science. There are many kinds of science, and the studies cited by Epstein are actually well-designed, good experiments.

My scientific training includes a Ph.D. in clinical psychology from the University of North Carolina at Chapel Hill. I have spent the past four decades as a psychotherapist and graduate school teacher. My reading of the professional literature and my therapeutic experience strongly support the personal and clinical benefits of the exercises mentioned by Epstein. I do these exercises in couples therapy, allowing the practice of powerful behaviors that really can bring a couple closer together. One of the most important outcomes is unlearning or relieving the common and strong anxiety many people experience because of the vulnerability inherent in emotional intimacy.

Therapy outcome research is extremely hard to do well. Moving from published science to creative therapeutic applications in real-life healing requires careful, extensive and long-term assessment of measurable treatment outcomes—a real challenge. Unfortunately, many clinicians pay little attention to the scientific literature and thereby miss both therapeutic options and reports of what does not prove useful over time.

Bob Dick
via e-mail

HOW MANY NEURONS?

Everything I have read says the brain has approximately 100 billion neurons. Paul Reber in Ask the Brains states one billion.

Phyllis Havard
Smither, B.C.

REBER REPLIES: *Thank you for pointing out the misstatement. One billion is a rough estimate of the number of neurons in the brain likely to be involved in memory for facts and events, not the total neurons in the brain. Curiously, nobody really knows exactly how many neurons there are in a human brain. A good recent estimate comes from a 2009 paper by neuroanatomist Susana Herculano-Houzel of the Federal University of Rio de Janeiro. By her estimate, 85 billion total brain neurons includes 65 billion in the cerebellum and only around 17 billion in the cerebral cortex. Fact memory is probably a function largely of the cerebral cortex and not the cerebellum. Given that there are a number of different types of neurons in the cerebral cortex and that there are many areas where the neurons do things other than help with memory, you can see how one billion is a conservative estimate I hoped would be useful for understanding the storage capacity of the human brain. Even if the true number is more than that, my point bears out—it is unlikely we could ever use up our storage space.*

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FLUENT IN DREAMS

Regarding "Once Learned, Never Forgotten," by Karen Schrock [Head Lines], I have been under the impression for years that once something such as a language is in the brain, it is never forgotten on a subconscious level. My mother was a hidden child during the Holocaust in French-speaking Belgium, and the experience was traumatic for her at such a young age. As she grew up, she lost the ability to speak French fluently; although she took French in college, she was no more fluent than any other college student who has had some classes.

But during the course of her life, she had dreams of Belgium in which any conversation would be in Belgian French without any feeling of limitation in vocabulary. In her dream state she simply knew Belgian French and not English anymore. It seems that all people have the language they learned as a child stick with them on a subconscious level, but it took the trauma my mother went through to spark her nightmares and show that to be the case.

Yisrael Asper
via e-mail

LAF KOWALZIK Getty Images

>> MENTAL HEALTH

Depression Drugs Affect Personality

Less neuroticism and more extroversion may be at the root of patients' improvement

Friends and family of people with depression may feel that their loved one has been replaced by a gloomy doppelgänger. According to recent research, however, it may be the treatment of depression that actually causes personality changes in people with the disorder.

Experts have long known that the placebo effect explains much of the mood lift patients report after going on antidepressants. This was the case in the new study, published in the journal *Archives of General Psychiatry*—patients with major depressive disorder who were given a placebo saw their symptoms improve about three quarters as much as those given paroxetine, an antidepressant also known as Paxil. But only the patients who took paroxetine displayed personality changes in two key areas of the widely used five-factor model of personality: they scored lower on neuroticism, the tendency to experience negative emotions such as guilt and anxiety, and they scored higher on extroversion, which includes traits such as talkativeness and assertiveness.

Personality traits are thought to be relatively stable over a person's life—even the onset of depression, which comes with unusually low moods, should not alter a person's fundamental traits. Personality can affect a person's risk for mental illness, however—past research has established neuroticism as a key risk factor for depression, explains Tony Tang of Northwestern University, the lead author of the study. Tang and his colleagues found that the more a patient's neuroticism dropped while taking paroxetine, the smaller the chance that his or her depression would return after they stopped taking the drug.

The study "proves in an elegant way that antidepressant medications and placebo have different actions in many cases," says Andrew Leuchter, a depression researcher at the University of California, Los Angeles, who was not a part of the study. "This may explain in part some of the ways that antidepressants have a therapeutic benefit for some patients." —*Allison Bond*

>> SOCIABILITY

Testosterone's Effect on Fair Play ...

The "aggression hormone" can sometimes cause people to be nicer to their peers

You know this guy: bellowing at the bar, cutting off cars in packed traffic or mocking a crestfallen sports star. He's the testosterone ape, the swaggering embodiment of male aggression.

For years scientists have pointed fingers at him as the living example of testosterone's brutish, self-centered, antisocial expression.

But Swiss neuroscientist Christoph Eisenegger of the University of Zurich wondered about this stereotype. To explore it further, he and his team designed a study involving women, not men, along with testosterone and the root of all evil, money. And he showed that when success depends on fair play, higher testosterone levels encourage cooperation instead of aggression.

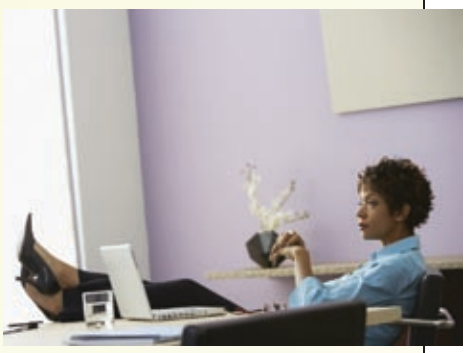
The study consisted of a simple, oft-analyzed game involving two people and one pile of money. One player offers a one-time deal on how to divide the money. If the second party accepts the split, both receive their shares. If she rejects it, nobody gets a cent.

The women who offered the deal were given either testosterone or a placebo. To ensure the testosterone would have an influence, the researchers gave the women enough testosterone to pump up their baseline levels by 400 percent. And after administering either the hormone or the placebo, the researchers asked the women to guess which one they had received.

Women who received a placebo but believed they had received testosterone offered fair money splits only 10 percent of the time, probably because they harbored a negative stereotype of testosterone's effects. Women who were given testosterone but thought it was a placebo, on the other hand, offered fair-share splits 60 percent of the time—significantly more often than those who correctly guessed they got testosterone (30 percent) or a placebo (50 percent).

Ultimately, Eisenegger says, the hormone's effects vary with the setting. It seems that testosterone feeds the drive to be victorious, no matter what the means are to that end. If being king of the hill is the goal, high testosterone levels can lead to verbal and physical aggression. But in situations where mutual benefit wins the prize, the same hormone engenders cooperation. *—Sandy Fritz*

CORBIS (*handshake*); AGE FOTOSTOCK (*feet on desk*)



>> STATUS

... and Posture's Effect on Testosterone

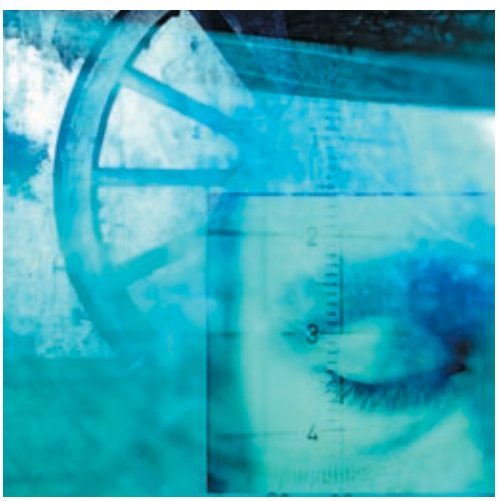
A dominant pose can send hormone levels spiking

Chances are your boss takes up a lot of space. Dominant animals show their status with expansive postures, and humans are no exception. Now a study suggests that these poses alter hormone levels. When researchers put subjects' feet up on a table or leaned their bodies forward over a desk, the volunteers experienced a rise in testosterone and a drop in the stress hormone cortisol. "Not only did people feel more powerful," says lead author Dana R. Carney, a psychologist at Columbia Business School, "but their physiology indicated that they were actually becoming more powerful." So put your feet up, then ask yourself: Who's the boss? ***—Frank Bures***

>> SLEEP

Dreamy Eyes

Why do our eyes flutter about during rapid eye movement (REM) sleep? To keep track of the actions and events in our dreams, says a study in the June issue of *Brain*. Researchers at Pitié-Salpêtrière Hospital in Paris studied people who have a disorder that makes them act out their dreams (but whose eye movements have been shown not to differ from healthy sleepers). Using electrodes to record eye movements and cameras to capture nighttime motions, the researchers found that where participants were looking and what they were doing synchronized 90 percent of the time. A subject dreaming about climbing a ladder, for instance, repeatedly gazed up and down to check his progress. *—Ferris Jabr*



GETTY IMAGES (*eye*)

>> PREFERENCES

Favorite Colors

We like hues that we associate with pleasant things

Evolutionarily speaking, it makes sense that people would approach or withdraw from objects based on their colors. Bright reds and yellows often mean ripe, delicious fruit, whereas drab yellowish-greens and browns signal … well, less pleasant things.

To test whether the objects most commonly associated with particular colors really do determine color preference, psychologists Stephen Palmer and Karen Schloss of the University of California, Berkeley, asked a group of volunteers to brainstorm all the common objects they associated with each of 32 colors. When presented with yellow, for example, they listed things such as bananas, canary birds and mustard, among other items. A second, separate group then rated the appeal of every object on a scale of negative 100 (icky) to 100 (lovely), and a third group rated how well each color matched each object (for instance, bananas are indeed highly associated with the color yellow, but mustard is less so, perhaps because some people think of it as closer to brown).

Based on all the ratings, the researchers calculated a mathematical weight for each color indicating the strength of its link with well-liked objects. Finally, a fourth group of volunteers indicated how much they liked or disliked the original 32 colors using a sliding scale. The experimenters found that the last group tended to like the colors with the highest weights—the colors the first three groups linked most strongly to pleasing objects.

The next question is, Are color cues for approach and withdrawal genetically etched into our brains? Or do our experiences shape our preferred palette? Palmer's group is now testing people from the U.S., Mexico and Japan to see if the colors and objects they like differ—and also to see if avid Berkeley football fans have come to hate their archrival Stanford's particular shade of cardinal.

—Mark Lescroart

>> MIND-BODY CONNECTION

Natural Immunity

Just looking at sick people protects against illness

Humans have a natural aversion to those who are ill. When we see others who seem under the weather, we experience a powerful emotional response—disgust—and do our best to avoid those who might be contagious. Now a study shows that seeing sick people can even prompt changes in the immune system.

Researchers at the University of British Columbia showed subjects one of two different slide shows—either a depiction of people brandishing guns or images of individuals who were obviously ailing. Immediately after the subjects viewed the slide shows, researchers drew their blood, exposed each sample to bacteria and then measured the levels of a substance known as interleukin-6 (IL-6), which is secreted by white blood cells as a response to stress or trauma. Although the subjects rated the gun photographs as being more stressful than the illness images, the blood work told a different story. Whereas the gun images prompted a mere 7 percent increase in IL-6, levels of the substance were elevated 24 percent after viewing pictures of sick people.

"It makes evolutionary sense that the immune system would respond aggressively only when it's really needed," says Mark Schaller, a psychologist and co-author of the study. "If I see a bunch of sick people, maybe a big infection is around, and I better kick my immune system into high gear." It is unclear exactly how an image gets translated into a mustering of immune cells, Schaller says, but many neurochemicals connect the brain to the immune system—more studies are needed to tease out the exact chain of events. ***—Emily Anthes***

GETTY IMAGES (*color palette*); GETTY IMAGES (*sick in bed*)

RELATIONSHIPS

All about My Mother

How that early bond subtly shapes decisions and moods

Strong emotional bonds between mothers and infants increase children's willingness to explore the world—an effect that has been observed across the animal kingdom, in people, monkeys and even spiders. The more secure we are in our attachment to Mom, the more likely we are to try new things and take risks. Now researchers are discovering that this effect continues into adulthood. A mere reminder of Mom's touch or the sound of her voice on the phone is enough to change people's minds and moods, affecting their decision making in measurable ways.

In a study published online in April in *Psychological Science*, undergraduate business students had to choose between safe bets and risky gambles—a bond with a guaranteed 4 percent yearly return or a riskier stock option, for example. In half the cases, the experimenters patted the students lightly on the back of the shoulder for about one second while providing verbal instructions about the study. Both male and female students who were touched by a female experimenter were far more likely to choose the risky alternative than were those who had not been touched or were patted by male experimenters. The reassuring touch of a woman may have triggered early associations, inspiring the same openness to exploration that is observed in young children of supportive mothers, explains Jonathan Levav, a business professor at Columbia University and lead author of the study.

To further confirm that a woman's touch links feelings of security with risk taking, the researchers asked a different group of undergraduates to make financial decisions after a writing exercise. Half of them wrote about a time they felt secure and supported, whereas the other half wrote about feeling insecure and alone. Evoking a sense of insecurity made students in the latter group especially receptive to the gentle shoulder pats from female experimenters and much more willing to take a risk—just as a child leaving for a field trip might steal one last reassuring hug from Mom before stepping on the bus.

But touch is not the only source of maternal comfort. In a study published online in May in the *Proceedings of the Royal Society B*, researchers at the University of Wisconsin–Madison stressed out a group of seven- to 12-year-old girls by giving them math and public-speaking exercises. Then they reunited some girls with their mothers but offered others only a phone call. The study found that girls who talked with their mothers on the phone released just as much oxytocin, the social bonding hormone, as those who got to hug their mothers. And both groups had similarly low levels of cortisol, a stress hormone, which might explain why so many people—young and old alike—call their mothers when feeling blue.

"What we are dealing with is very fundamental," Levav says. "It comes down to the simple reason that your mom was the first one to hold you." And the effects of that bond last for a lifetime.

—Ferris Jabr

GEORGE MARKS Getty Images (*mother and children*); IMAGES.COM/CORBIS (*man at crossroads*)

BRAIN IMAGING

Trying to Do Too Much

Brain structure explains why people have difficulty multitasking

When we do two things at the same time, our brain divides the work in half, literally: each hemisphere concentrates on one task, reports a study in the April 16 issue of *Science*. Researchers measured brain activity in volunteers performing letter-pairing tests. When subjects had to deal with two streams of letters, concurrently performing two pairing tasks, the activity in one half of the brain corresponded to one task, and the activity in the other half corresponded to the other task. The study might explain why people are notoriously poor at doing three or more things simultaneously. After two tasks, we run out of hemispheres.

—Graciela Flores

>> MOTIVATION

Slackers Better at "Fun" Activities

Reminding low achievers of the importance of a task may backfire

Every teacher knows there are students who always seem to be a step ahead of everyone else. And then there are the slackers, who are just as intelligent but who don't seem to mind being mediocre. The difference seems obvious: some people are inherently motivated to succeed, whereas others simply don't care. But a study conducted by psychologists William Hart, now at the University of Alabama, and Dolores Albarracin of the University of Illinois suggests otherwise. Simply reframing a task as "fun" caused the underachievers to outperform those who usually excelled—indicating that the way an educator describes an activity might have a powerful influence on how well students do on it.

The researchers first screened participants of comparable academic ability, categorizing them as interested in achievement or interested in fun. They then had the students look at a computer screen that flashed words related to high achievement (for instance, "win," "excel" and "master"). In subsequent tests of ability such as a word-search puzzle, the participants who were interested in achievement performed significantly better than did those who were not.

That experiment confirmed conventional assumptions, but the next one had a confounding outcome. Participants were again primed with high-achievement words and asked to complete a word-search puzzle. But instead of describing the task as a serious test of verbal proficiency as before, the researchers called it "fun." The results of that simple semantic change were profound: not only did the supposed slackers perform better on the task this time around, their scores actually surpassed those of the high-achievement crowd.

The study authors point out that for some students, when a task is portrayed as "fun," not only does their motivation improve, but their performance does, too. Educators and parents should take note, the researchers say, and be careful to frame activities so that they engage students with a range of learning styles.

—David DiSalvo

>> PLEASURE

Money Buys Unhappiness

Thinking about cash impairs the ability to savor experiences

"'Tis the gift to be simple," the Shakers sing. Catholic nuns and Buddhist monks take vows of poverty. Why? A new study published online in May in *Psychological Science* offers a hint. Money—even the thought of it—reduces satisfaction from life's simple pleasures.

Studies have shown that a person's ability to savor experiences predicts their degree of happiness. Savoring is defined as the emotions of joy, awe, excitement and gratitude derived during an experience. Psychologist Jordi Quoidbach of the University of Liège in Belgium and his colleagues divided 374 adults, ranging from custodians to senior administrators, into two randomly assigned groups. The first group was shown a picture of a stack of money; the control group was shown the same picture blurred beyond recognition. Then the participants were given psychological tests to measure their ability to savor pleasant experiences. The results showed that people who had been shown the money scored significantly lower.

A second test showed even more dramatically how the thought of cash spoils savoring. Participants were given a piece of chocolate after being shown a picture of money or a blurred photograph. Then an observer timed how long the person savored the morsel of chocolate. Women savored the chocolate longer than men, but regardless of gender, individuals shown the picture of money beforehand spent significantly less time savoring the chocolate—on average, 32 seconds versus 45 seconds.

In other words, what money gives with one hand—access to pleasurable experience—it takes away with the other by robbing people of the ability to appreciate simple joys. Think about that the next time you are considering splurging at an expensive restaurant when you could be heading off to a picnic with a bottle of wine, crusty French bread, tangy cheese and, for dessert, a bite of chocolate.

—R. Douglas Fields

GETTY IMAGES (*classroom*); IMAGES.COM/CORBIS (*man in money stocks*)

SEBASTIEN ROCHE-LOCHEN /*Stockphoto (coffee and cigarette)*; DREAMPICTURES/GETTY IMAGES (*soldier*)

>> BASIC SCIENCE

Prescription: Coffee and Cigarettes

Discovering why even bad habits can protect the brain

Inspired by human studies showing that avid coffee drinkers and smokers have a lower risk of Parkinson's disease, scientists at the University of Washington decided to see what java and cigarettes do to fruit flies. The tremors and other movement impairments of Parkinson's are triggered by the death of dopamine-producing cells in the brain, so the investigators used flies that had been genetically engineered to have their dopamine cells die off as they age. When Leo Pallanck and his colleagues fed coffee and tobacco extracts to these flies, they found that the animals' dopamine cells survived and their life span increased. The scientists ruled out caffeine and nicotine as the protective substances, but there are other promising compounds in coffee and tobacco, which the researchers intend to test in these short-lived creatures. "Flies are a great system for quickly trying to zero in on the chemicals that are responsible," Pallanck says. —*Michele Solis*

>> EXPERIMENTAL MEDICINE

Ecstasy Triumphs over Agony

An illicit drug shows promise as a treatment for post-traumatic stress disorder

In dance clubs the drug called "ecstasy" is known as a potent (and illegal) way of enhancing your senses and boosting your mood. Now a study published online in July in the *Journal of Psychopharmacology* suggests that when coupled with psychotherapy, the drug might also be an effective treatment for post-traumatic stress disorder (PTSD).

South Carolina psychiatrist Michael Mithoefer, along with his co-therapist and wife, Annie Mithoefer, ran the trial with 21 participants who had developed chronic, treatment-resistant PTSD as a result of experiences with crime or war. They gave each participant two sessions with either MDMA (3,4-methylenedioxymethamphetamine, which is ecstasy's chemical name) or a placebo. Those who received MDMA took 125 milligrams, comparable to an amount a recreational user might take in a club, as their psychotherapy session began. Two and a half hours later, as the session progressed, subjects took a booster dose of half that amount to ensure the effects continued. The placebo group got sugar pills at corresponding times, and both groups received about eight hours of psychotherapy in total.

Two months after the treatment fewer than 17 percent of the MDMA-treated subjects continued to qualify for a diagnosis of PTSD, as opposed to 75 percent of the subjects who received a placebo. "Our results are encouraging, and we had no significant safety problems. The next step is to find out if these results can be replicated elsewhere," says Mithoefer, who is in private practice near Charleston. The study, sponsored by the Santa Cruz–based nonprofit Multidisciplinary Association for Psychedelic Studies, was the first FDA-approved trial evaluating MDMA's therapeutic applications. More trials of ecstasy for PTSD are under way in Switzerland and Israel, with other studies starting soon in Canada, Jordan and Spain.

Mithoefer considers the findings especially notable given that 20 of the 21 participants had previously failed to obtain relief with currently approved medications and with at least one course of psychotherapy. PTSD is notoriously difficult to treat, affecting an estimated 7.8 percent of Americans.

So why does MDMA work when current medications do not? The leading theory, proposed by Mithoefer, builds on a

therapeutic technique in which patients are exposed to their disturbing memories in a safe environment. To be effective, the theory goes, exposure therapy must be accompanied by a degree of emotional engagement, while avoiding dissociation or overwhelming emotion. PTSD patients often have a narrow window between thresholds of underarousal and overarousal. If MDMA widens this window, allowing patients to stay emotionally engaged while revisiting traumatic experiences, then it may catalyze effective exposure therapy.

In addition, MDMA elevates the hormone oxytocin, which is involved in feelings of affiliation and trust. Higher levels of oxytocin might help patients to form a more trusting bond with their therapist, so that they may revisit traumatic experiences in an emotionally engaged state. —*David Jay Brown*

>> CHOICES

Green and Mean

Buying eco-friendly products might make you more likely to behave badly later on

So you decided to buy a nontoxic cleaning product? Good for you. Just don't get too self-congratulatory. Purchasing a green product could make you more likely to behave more selfishly down the road, a new study reveals.

Researchers at the University of Toronto asked college students to shop for products online from either an eco-friendly or a conventional store. Then, in a classic experiment known as the dictator game, subjects were asked to divide a small sum of money between themselves and a stranger. Those who shopped at the green store shared, on average, less of their money.

The investigators believe that a "licensing effect" might be at work. "When we engage in a good deed, that gives us a kind of satisfaction," says Nina Mazar, professor of marketing and a co-author of the paper. With that self-satisfied feeling can come tacit permission to behave more selfishly next time we have the opportunity, Mazar says. Previous research has documented this licensing effect in other contexts; a study published last year revealed that asking people to ruminate on their humanitarian qualities actually reduced their charitable giving.

Next, Mazar is particularly interested in exploring the policy implications of this licensing effect; for instance, one study suggested that people who make their homes more energy-efficient start cranking up their heat. She hopes to determine whether simply making people aware of these kinds of tendencies could help combat them. —*Emily Anthes*

>> ADDICTION

How Smokers Think about Death

Do graphic warning labels on cigarette packages really deter people from lighting up?

In 2012 the U.S. will join dozens of nations around the world in labeling cigarette packages with large photographs of diseased organs, amputated limbs and other gruesome images. Previous research has borne out the idea that when people see images of cigarette-induced ailments, they are reminded of their own mortality. But a study presented in May at the annual meeting of the Association for Psychological Science suggests that reminders of mortality might not always have the desired effect.

Jamie Arndt, a psychologist at the University of Missouri, had student smokers complete questionnaires designed to induce either thoughts of their own mortality or thoughts about failing an exam. Then the researchers offered the students a cigarette and measured every person's smoking intensity—each puff's volume, flow and duration. Students who did not smoke often indeed smoked with less passion after being reminded of their own mortality, as compared with the light smokers who read about failing an exam. As Arndt explains, the infrequent smokers may have been responding to thoughts of death by trying to reduce their own vulnerability. But students who were heavy smokers reacted to thoughts of death by taking even harder drags on their cigarettes. Arndt suggests they might have been subconsciously attempting to dispel a negative mood with an enjoyable activity. Although the reason is unclear, the finding suggests that the psychology involved in smoking and thinking about death is more complicated than previously assumed. Therefore, graphic warning labels on cigarettes might not have the intended effect on everyone who sees them. —*Karen Schrock*

JETTA PRODUCTIONS/GETTY IMAGES (*recycling guy*); JUPITERIMAGES (*smoker*)

>> MORALITY

You're Happy, I'm Happy

Fairness can matter more to people than their own self-interest

An unfair situation is enough to get anyone's hackles up. But is our aversion to inequity innate or the product of our social mores? A new study published in *Nature* suggests that biology does play a role: the brain's reward centers respond more strongly to situations in which people are treated equally as opposed to unfairly, even when fairness comes at a personal cost.

Researchers gave pairs of young men $30 each and then randomly picked one of them to receive a $50 bonus. Using functional MRI, they scanned each of the men's brain activity while asking them to judge how they would feel if an additional one-time gift of more cash went to themselves or to the other person in the pair. As expected, when the man who had not received the bonus imagined getting the gift, his ventral striatum and ventromedial prefrontal cortex—brain areas associated with reward—became active. But surprisingly, when the man who had received the initial bonus imagined the other subject getting the gift, his reward centers lit up, too. In other words, his brain responded favorably to an act that reduced inequality but was not in his best interest.

Although the data suggest that an appreciation for fairness is at least partly biological, no one yet knows whether it is innate or learned, because both genetics and experience can affect brain processes, explains study co-author Elizabeth Tricomi, a psychologist at Rutgers University. "It is not unreasonable, however, to think that there could be an evolutionary benefit to a preference for fairness. Fairness helps us work together, which can benefit everyone," she says.

—Melinda Wenner Moyer

CORBIS (*equal sign*); KEVIN CURTIS *Photo Researchers, Inc.* (*boy with blocks*)

>> INTERACTING

Hormonal Help for Autism

Taking oxytocin boosts social skills in people with the asocial disorder

When we engage in intimate social interactions, the "trust hormone" oxytocin likely plays a role—it is vital to building normal relationships. Even a synthetic version has been shown to boost feelings of security. Now increasing evidence suggests that oxytocin could also correct some of the interpersonal deficiencies experienced by those who have autism.

In a study published in February in the *Proceedings of the National Academy of Sciences USA,* 13 high-functioning adults with autism played a computerized ball-tossing game with three fictitious characters. Some of the computer-controlled players behaved less cooperatively than others, and to succeed at the game, subjects needed to identify them and avoid passing them the ball. When given a placebo, those with autism could not differentiate among playmates. After the patients received oxytocin, however, their performance resembled that of people without autism—they favored the more cooperative players.

"Not only can people with autism socialize more under the effect of oxytocin, they can understand the behaviors of others and respond accordingly," explains study co-author Angela Sirigu, director of research at the Center for Cognitive Neuroscience in Bron, France.

Previous studies have found that oxytocin enhances autistic adults' ability to comprehend emotions in speech and tamps down repetitive behaviors, another common symptom of the disorder. The compound also helps autistic children better discern people's intentions by reading their eyes.

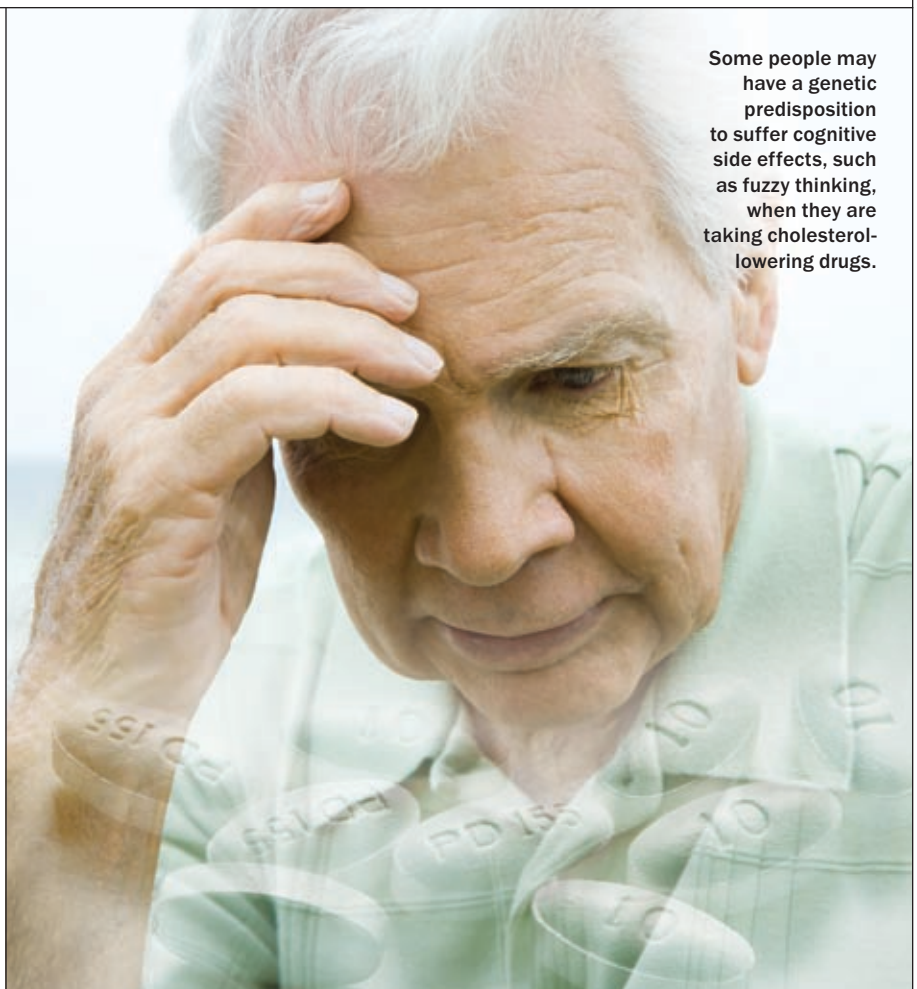
Although these studies are only proofs of principle—many more trials must happen before a drug could be approved—they suggest that oxytocin, if delivered soon after a diagnosis of autism, could help sway early social interactions in favor of more normal development. "We don't have a lot of medications for the core symptoms of autism—arguably we have none," says Thomas R. Insel, director of the National Institute of Mental Health. "So if this has any impact, you want to try it."

—Nikhil Swaminathan

It's Not Dementia, It's Your Heart Medication

Why cholesterol drugs might affect memory

BY MELINDA WENNER MOYER



Some people may have a genetic predisposition to suffer cognitive side effects, such as fuzzy thinking, when they are taking cholesterol-lowering drugs.

CORBIS (*man*); CHRIS GALLAGHER *Photo Researchers, Inc.* (*Lipitor pills*)

ONE DAY IN 1999 Duane Graveline, then a 68-year-old former NASA astronaut, returned home from his morning walk in Merritt Island, Fla., and could not remember where he was. His wife stepped outside, and he greeted her as a stranger. When Graveline's memory returned some six hours later in the hospital, he racked his brain to figure out what might have caused this terrifying bout of amnesia. Only one thing came to mind: he had recently started taking the statin drug Lipitor.

Cholesterol-lowering statins such as Lipitor, Crestor and Zocor are the most widely prescribed medications in the world, and they are credited with saving the lives of many heart disease patients. But recently a small number of users have voiced concerns that the drugs elicit unexpected cognitive side effects, such as memory loss, fuzzy thinking and learning difficulties. Hundreds of people have registered complaints with MedWatch, the U.S. Food and Drug Administration's adverse drug reaction database, but few studies have been done and the results are inconclusive. Nevertheless, many experts are starting to believe that a small percentage of the population is at risk, and they are calling for increased public awareness of the possible cognitive side effects of statins—symptoms that may be misdiagnosed as dementia in the aging patients who take them.

Fat and the Brain

It is not crazy to connect cholesterol-modifying drugs with cognition; after all, one quarter of the body's cholesterol is found in the brain. Cholesterol is a waxy substance that, among other things, provides structure to the body's cell membranes. High levels of cholesterol in the blood create a risk for heart disease, because the molecules that transport cholesterol can damage arteries and cause blockages. In the brain, however, cholesterol plays a crucial role in the formation of neuronal connections—the vital links that underlie memory and learning. Quick thinking and rapid reaction times depend on cholesterol, too, because the waxy molecules are the building blocks of the sheaths that insulate neurons and speed up electrical transmissions [*see illustration on opposite page*]. "We can't understand how a drug that affects such an important pathway would not have adverse reactions," says Ralph Edwards, former director of the World Health Organization's drug-monitoring center in Uppsala, Sweden.

Two small trials published in 2000 and 2004 by Matthew Muldoon, a clinical pharmacologist at the University of Pittsburgh, seem to suggest a link between statins and cognitive problems. The first, which enrolled 209 high-cholesterol subjects, reported that participants taking placebo pills improved more on repeated tests of attention and reac-

> Subjects who were taking statins did not show normal improvement, suggesting their **learning was impaired**.

tion time taken over the course of six months—presumably getting better because of practice, as people typically do. Subjects who were on statins, however, did not show the normal improvement—suggesting their learning was impaired. The second trial reported similar findings. And a study published in 2003 in *Reviews of Therapeutics* noted that among 60 statin users who had reported memory problems to MedWatch, more than half said their symptoms improved when they stopped taking the drugs.

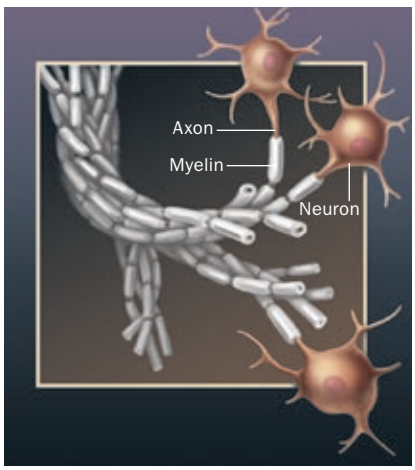
But other studies have found no significant link between statins and memory problems. Larry Sparks, director of the Laboratory for Neurodegenerative Research at the Sun Health Research Institute in Sun City, Ariz., goes so far as to say that "you've got a better chance of buying a winning lottery ticket, walking outside and getting hit by lightning and dying" than you do of suffering a cognitive side effect from statins.

Vulnerable Genes?

Many experts agree that for most people the risk is quite low, but they are beginning to believe the effects are real. "A subset of the population is vulnerable," argues Joe Graedon, co-founder of the consumer advocacy Web site the People's Pharmacy, which has collected hundreds of reports of cognitive-related statin side effects in the past decade. Some researchers believe these people have a genetic profile that puts them at risk.

Beatrice A. Golomb, an associate professor of medicine at the University of California, San Diego, suggests that one at-risk group may be people with defects in their mitochondria, the structures within cells that make energy. Statins prevent the body from making an antioxidant that neutralizes the damaging free radicals created by mitochondrial activity. If brain cells—which consume lots of energy—already have mitochondrial problems, then statin therapy could tip the scale and cause noticeable symptoms, such as trouble learning.

Golomb's theory is supported by a 2006 study published by geneticist Georgirene Vladutiu of the University at Buffalo. Vladutiu reported that statin users who experience muscle pain and weakness as a side effect are more likely than other users to have preexisting genetic defects related to cellular energy production. And as with brain cells, muscle cells are high energy users.



Statins may prevent the body from making cholesterol-based myelin, which insulates axons and speeds neuron communication.

Different Formulations

Interestingly, some studies suggest that statins might improve memory in certain people by lowering the risk of dementia. This benefit could occur because cholesterol is involved in the production of the protein clusters that are the hallmark of neurodegenerative diseases such as Alzheimer's and Parkinson's. But even if statins are neurologically protective for some, they may be problematic for others, given that the opposing effects probably arise through different biochemical pathways.

Because statins differ in their formulations and can affect so many processes, and because users have different genetic predispositions, simply switching drugs might help people who are experiencing warning signs such as forgetting names. A 2009 *Pharmacotherapy* study published by Golomb and Marcella A. Evans, a graduate student at the University of California, Irvine, analyzed the characteristics of 171 statin users who reported cognitive side effects. Their findings suggest that people who take the more potent statins—Crestor and Lipitor—are at an increased risk compared with people who take weaker statins.

Graveline, for one, is certain that Lipitor was to blame for his 1999 amnesia incident. Although he immediately stopped taking the drug, his doctor—who was skeptical—convinced him a year later to give it another shot. Sure enough, after another eight weeks of treatment, he suffered a second episode. Graveline has been statin-free ever since, instead following a healthy diet to keep his cholesterol low, and he says he has never felt better. But he also knows that for many, the benefits that statins provide will overshadow their risks. "I'm not asking for statins to be taken off the market," he says. "I'm just asking for physicians to be aware of their side effects." M

MELINDA WENNER MOYER is an award-winning science writer based in Brooklyn, N.Y.

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JEN CHRISTIANSEN

You Must Remember This

What stays with us, and what we forget, depends in part on how well our neurons keep time

BY CHRISTOF KOCH

Unusual and emotionally resonant events are particularly indelible. But the natural rhythms of the brain also play a role in what we recall.

ONE OF THE SIGNATURE discoveries of cognitive neuroscience is that a structure called the hippocampus, deep within the brain, is intimately involved in creating memories. This fact was dramatically illustrated by a singular patient, Henry Molaison, who experienced severe epileptic seizures. In 1953, when Molaison was 27, doctors removed his hippocampus and nearby areas on both sides of his brain. The operation controlled his epilepsy, but at a price—from that time on, he was unable to remember the things that happened to him. He could learn skills, such as mirror writing, but would be puzzled by his expertise, because he could not recall having acquired it.

H.M., as he was known during his lifetime to protect his privacy, taught scientists three lessons. First, certain brain structures—the hippocampus and the amygdala, the brain's emotion center—specialize in remembering. Second, there are different kinds of memory—the ability to recall facts, or personal experiences, or physical skills like riding a bike—each with its own properties. Third, memory is distinct from the brain's intellectual and perceptual abilities.

Fifty years later these conclusions have been strengthened by laboratory studies on mice, rats and monkeys and by further clinical observation. A case in point is transient global amnesia, a rare but enigmatic loss of memory that is sometimes triggered by a stressful event. The patient suddenly cannot recall facts or experiences—anything that is not deeply encoded, such as his name. He also becomes unable to form new memories. There is no impairment in motor or sensory function, judgment, intellectual faculties or consciousness. As the name suggests, transient global amnesia is temporary, disappearing within 24 hours with little long-term effect. But within a day or two of the attack, high-resolution imaging reveals small areas of damage in a specific part of the hippocampus.

Having established the critical role of the hippocampus, the next question is: What makes something memorable? Of the countless things a person encounters in a given day, why do some become indelibly imprinted, whereas others vanish like soap bubbles? Scientists know that many factors play a role in determining what people remember, among them how much attention the person is paying, how novel and interesting the experience is, and the kinds of emotions that are evoked. But recently a team led by neuroscientist Ueli Rutishauser of the Howard Hughes Medical Institute at the California Institute of Technology delved into the cellular workings of the hippocampus, chronicling the activity of individual brain cells as people absorbed and recalled new information. Their findings, though delivered in the technical language of action potentials and electrical frequencies, provide intriguing insights into the Proustian mystery of memory.

Electrodes Thinner Than a Hair

Epilepsy treatments, though less invasive than in H.M.'s day, continue to offer unique opportunities for neuroscientific insight. To pinpoint where seizures originate, doctors sometimes implant electrodes thinner than a hair in the affected brain areas. Then for a few days they eavesdrop on the electrical activity that takes place while the patient talks, watches television, moves around and sleeps in the hospital ward.

Rutishauser and his colleagues piggybacked their memory experiment on this medical protocol. They asked nine epileptics who were undergoing electrode monitoring to view 100 slides, each of which showed an image of a person, an animal, or an everyday object such as a car or a tool. The patients had one second to commit each picture to memory as best they could before the next one appeared. The team later tested the patients' recall by showing them a second set of 100 photographs, half of which were novel and half of which were repeats from the ini-

CHRISTOF KOCH (*Koch*); GETTY IMAGES (*old photographs*)

How do **three pounds of viscous tissue** hold a lifetime of accumulated impressions, recollections and knowledge?

tial slide show, and asking them to identify which ones they had already seen. During the two slide shows, the team used the implanted microelectrodes to track electrical activity in the hippocampus and the amygdala.

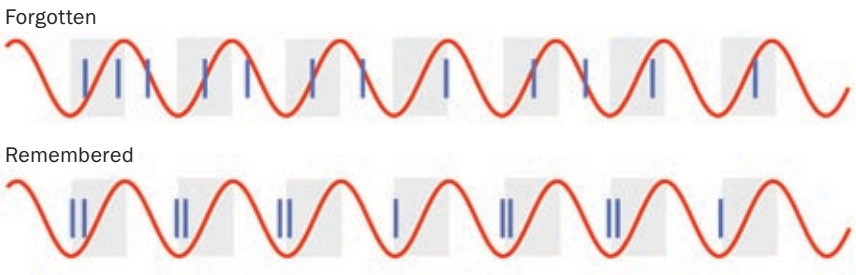
The electrical fields that are picked up by this technique include a variety of rhythms. Delta waves—slow brain waves that occur one to four times a second—are characteristic of deep sleep. Beta waves, which occur 12 to 30 times per second, dominate when people are actively concentrating.

At a middle tempo is the theta rhythm, which repeats three to 10 times per second. (To put this in perspective, consider that when I run along the steep trails in the San Gabriel Mountains, my heart rate plateaus at 160 beats per minute, or 2.6 beats per second.)

The theta rhythm is particularly strong when people are finding their way or looking at something novel—in other words, when they are learning. Previous experiments suggest that the stronger these oscillations are and the more often they occur during learning, the better the person will remember the new material.

So it was not a surprise that the Rutishauser team picked up prominent theta activity when the patients were memorizing the images. But their findings went deeper. Using sensitive electronics and sophisticated software, the scientists could detect the faint staccato sounds that individual neurons make as they send information to one another by way of all-or-none pulses known as spikes.

The team recorded the activity of 305 neurons in the hippocampus and the amygdala. The total number of spikes that occurred while a subject viewed an image did not predict whether or not the patient would later recall it. (On average, participants recognized two out of three of the initial pictures.) Yet the scientists found something that did predict successful recall in about one fifth of cells.



Scientists recorded the activity of individual neurons (*blue lines*) during a memory task. TOP: Neurons fire randomly, and the information is not retained. BOTTOM: Neurons spike during regular troughs in the theta wave (*red line*), which dominates during learning; recall improves.

SOURCE: UELI RUTISHAUSER

Getting into a Groove

Nerve cells do not generally operate in lockstep. They typically send out pulses irregularly, whenever their excitation levels exceed a threshold. What the Caltech team found, however, is that neuronal rhythms can be highly orchestrated at times—and that this synchrony helps people form lasting memories. Think about a freestyle swimmer. She regularly turns her head to the side to breathe within the triangle formed by her upper and lower arm and the waterline. If she takes a breath during a different phase of the crawl, she most likely will swallow water and lose her rhythm. And so it seems to be for these memory-forming neurons.

During the learning phase, the team found, if a picture flashed on the screen at a moment when neuronal spikes in the hippocampus and the amygdala lined up with the local theta clock, patients were more likely to remember the image and feel confident that their recollection was accurate [*see illustration at left*]. When people were viewing images that they would later fail to recognize, this coordination between individual memory-encoding neurons and overall brain activity was much reduced.

This research reveals an extra factor besides attention, novelty and emotional impact in determining what makes something memorable: timing. Neurons always spike in response to new images and experiences. But when the spikes happen to coincide with the theta rhythm, this coordinated electrical activity alters the brain's synapses, those specialized molecular machines between neurons, enabling memories to form.

These subtle findings help to decode the mechanics of memory—how three pounds of viscous tissue produces a mind possessed of innumerable impressions, recollections and knowledge accumulated over the course of decades. 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.

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Reading between the Lines

When an object is partially hidden, the brain deftly reconstructs it as a visual whole

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

CORBIS

IMAGINE THAT you are looking at a dog that is standing behind a picket fence. You do not see several slices of dog; you see a single dog that is partially hidden by a series of opaque vertical slats. The brain's ability to join these pieces into a perceptual whole demonstrates a fascinating process known as amodal completion.

It is clear why such a tendency would have evolved. Animals must be able to spot a mate, predator or prey through dense foliage. The retinal image may contain only fragments, but the brain's visual system links them, reconstructing the object so the animal can recognize what it sees. The process seems effortless to us, but it has turned out to be one of those things that is horrendously difficult to program computers to do. Nor is it clear how neurons in the brain's visual pathways manage the trick.

In the early 20th century Gestalt psychologists were very interested in this problem. They devised a number of cunningly contrived illusions to investigate how the visual system establishes the continuity of an object and its contours when the object is partially obscured. A striking example of amodal completion is an illusion devised by Italian psychologist Gaetano Kanizsa. In one view, you see a set of "chicken feet" arranged geometrically (*a*). But if you merely add a set of opaque diagonal bars, a three-dimensional cube springs into focus seemingly by magic, the chicken feet becoming cube corners (*b*).

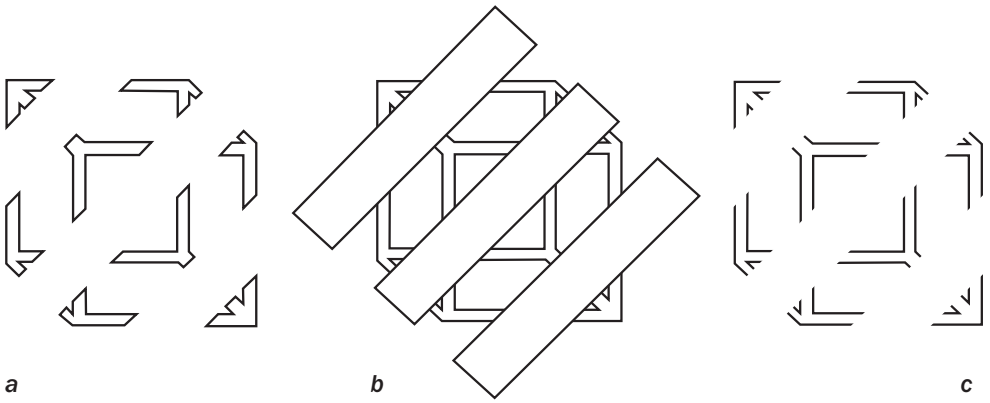
The astonishing thing is you do not even need to overlay real bars—even illusory ones will do (*c*). Here the otherwise inexplicable absence of boundaries terminating the chicken feet leads the brain to automatically infer the presence of opaque bars. So you see an illusory cube occluded by illusory bars!

The term "amodal completion" was coined to distinguish it from modal completion. Modal completion is the brain's tendency to see the full outline of a nonexistent object, as occurs in Kanizsa's classic triangle illusion (*d*). The brain regards it as highly improbable that some sneaky visual scientist has placed three

When you notice a wagging tail under the sofa and recognize that **a dog must be attached**, that is a logical inference.

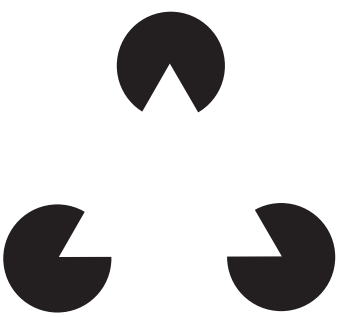
black disks with pie-shaped wedges cut out of them precisely in this manner, preferring instead to see an opaque white triangle that is partially covering three black disks.

Note, however, that modal and amodal completion can coexist. For example, in the Kanizsa triangle, the brain amodally completes each disk behind the corners of the illusory triangle. Similarly, in figure *c* the illusory bars are modally completed, whereas the cube is amodally completed.



a *b* *c*

Peter U. Tse, a cognitive psychologist at Dartmouth College, has devised many elegant illusions to explore modal and amodal completion. One of them, shown in figure *e*, is ambiguous, as are many of our favorite illusions. There is a strong bias to see this figure as a stack of rings (amodally completed) encircling an opaque (modally completed) illusory cylinder. Yet one might have a very different take, seeing no cylinder and instead a column of C-shaped metal arches with the sharp ends facing forward. The bias toward seeing rings occurs because it better reflects the real world, which abounds in 3-D objects that occlude one another. Another of Tse's illusions (*f*), which we fondly call "alien grabbing the last doughnut," also has both modal and amodal aspects. It looks like a bunch of squiggles until the eye discerns a series of tentacular fingers coiled around a doughnut-shaped tube.

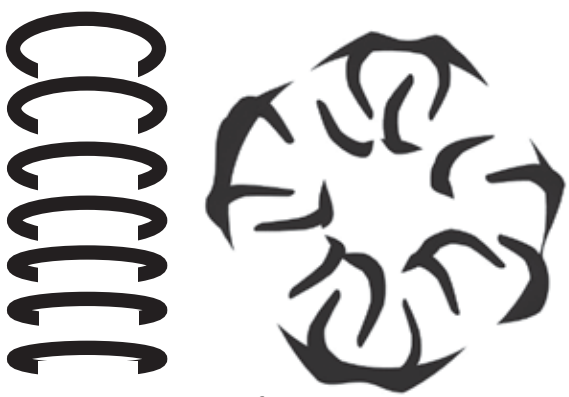


d

The Transparent Tunnel

You might think amodal completion involves reasoning ("there is a fence in the way, which is why I'm seeing slices of dog"), but in fact it is a perceptual phenomenon requiring no cogitation.

When you notice a wagging tail protruding from under the sofa and recognize that a dog must be attached, that is a logical inference. Whereas if the dog's head were sticking out from the other side of the sofa, then in an automatic and effortless manner, via amodal completion, you would perceive a whole dog without actually seeing its hidden parts.

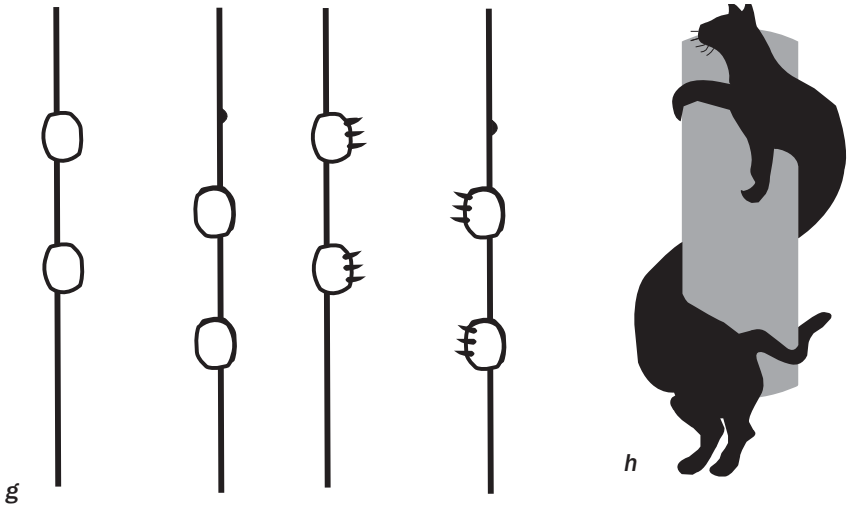


e *f*

Similarly, when you see a person's two arms forming a cross, there are two possible interpretations. A malicious surgeon may have amputated an arm and pasted the two halves on either side of the intact arm—or one arm may simply be placed perpendicularly in front of the other. Your visual system instantly sees that the latter is true; you do not even consider the former interpretation. Again, this is not because of high-level knowledge about the improbability of amputated arms—note that the brain has the same instantaneous reaction when the cross is made of wood, which could quite easily and bloodlessly have been sawed into pieces.

Borderline cases exist, however, such as the bear you "hallucinate" behind a tree (*g*). This drawing seems to show only circles bisected by lines, until the addition of what appear to be claws makes the dot at the top right morph into a nose and the circles into paws. Such examples blur the distinction between seeing and knowing. For instance, if you observe a fast-moving toy train go into a short tunnel and emerge on the other side within a third of a second, you will actually "see" the motion of the train, as if

SCIENTIFIC AMERICAN MIND, SOURCES: GAETANO KANIZSA (*a*, *b*, *c*); STEVE LEHAR (*d*); PETER U. TSE (*e*, *f*)



g h

the tunnel were transparent. You have modally completed the motion across the tunnel—a phenomenon first pointed out by Gestalt psychologist Albert Michotte (1881–1965).

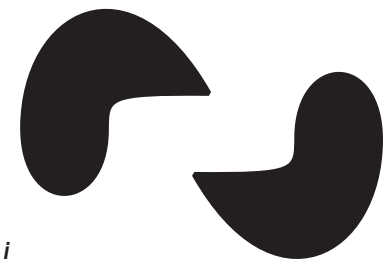
If the train is slow, on the other hand, taking a minute or more to traverse the tunnel, you still know that a single train entered and then emerged on the other side, but this time it is a logical inference rather than a visual perception. At speeds of about a second, however, you are in a borderline state between perception and logic, and the question of whether you actually "see" the train's movement comes perilously close to being a philosophical one.

Elongated Cats

The tendency to anticipate contours is so strong it overrides our knowledge of how the world actually works—as demonstrated, for example, when a cat seems unrealistically stretched around a tree (*h*): the brain is responding to continuity, independent of whether it makes sense or not.

Such visual anomalies occur because these rules are evolutionarily ancient and were not designed to handle improbable juxtapositions created by scientists. Programming sophisticated object knowledge into the system would have been too demanding—and unnecessary. Only in myth and fantasy do animals abruptly morph into unaccustomed shapes.

According to hierarchical views of visual processing, the detection of edges in a two-dimensional drawing is a relatively simple process that necessarily precedes the act of constructing high-level 3-D representations. Other figures designed by Tse challenge this conclusion.

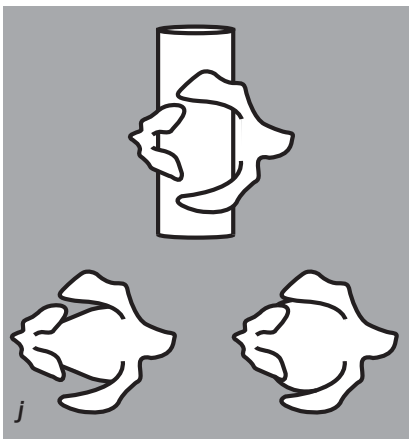


i

The simplest is his lab's logo (*i*). It can be seen either as two flat bird heads (one of them upside down) or as a 3-D black worm wrapped around a white cylinder (the worm is amodally completed by the presence of the cylinder). Unlike the Kanizsa triangle, in which the three disk regions align, implying the existence of edges, in this Tse figure there is no direct continuity of luminous edges or physical contours. And yet the brain perceives the 3-D worm. These illusions suggest that amodal completion is not only a matter of filling in continuous contours. The visual system is cleverer than that. In fact, in another Tse creation (*j*), objects complete amodally behind contours without their exact shape even being specified.

Object Lessons

In their pioneering work in the 1960s, neurobiologists David H. Hubel and Torsten N. Wiesel of Harvard University showed that brain cells in the primary visual cortex respond principally to the dark/light edges that convey the contours of an object or creature. Rudiger von der Heydt of Johns Hopkins University has subsequently shown that cells in the secondary visual cortex respond to illusory contours such as those of the Kanizsa triangle (*d*).



j

All of which reminds us that a key goal of vision is to detect objects (not merely contours), using any information that happens to be available. Both modal and amodal completion, and the illusions they inspire, derive from this elementary visual imperative. 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)

- **Filling in the Blind Spot.** V. S. Ramachandran in *Nature,* Vol. 356, page 115; March 12, 1992.
- **Amodal Completion in the Absence of Image Tangent Discontinuities.** P. U. Tse and M. K. Albert in *Perception,* Vol. 27, No. 4, pages 455–464; 1998.
- **Filling-in: From Perceptual Completion to Cortical Reorganization.** Edited by Luiz Pessoa and Peter De Weerd. Oxford University Press, 2003.
- **Brain and Visual Perception: The Story of a 25-year Collaboration.** David H. Hubel and Torsten N. Wiesel. Oxford University Press, 2004.

SCIENTIFIC AMERICAN MIND, SOURCES: V. S. RAMACHANDRAN (*g*); PETER U. TSE (*h, i, j*)

(calendar)

September

20 We often refer to a strong sexual attraction as animal magnetism, but arousal involves more than just base instinct. At the **Mind Science lecture series**, psychologist Stephanie Ortigue will describe how desire depends on complex mental processing. Her talk, "The Consciousness of Desire," will reveal the brain regions associated with longing and how they are influenced by mirror neurons—brain cells that fire when we either perform or observe an action.
San Antonio, Tex.
www.mindscience.org/events/index.cfm

JANA LEON Graphistock/Corbis (DNA head); NICK BALLON Getty Images (heads in boxes)

October

1 At its core, economics is the study of incentives—why people do what they do—according to Steven Levitt and Stephen J. Dubner, authors of the book **Freakonomics**. In their documentary film adaptation of the best seller, Levitt and Dubner apply economic theory to human behavior in real-life scenarios. Among other provocative ideas, they explore the consequences of baby-naming—does giving your baby a suggestive name, such as "Temptress," seal her fate?—and propose that making abortion legal and available may actually reduce the population of dysfunctional children.
Nationwide
www.magpictures.com

28 What motivates people to keep in shape? If you live near a park or in a ritzy part of town, you may be more inclined to walk than to hop in a cab or train. Although desirable surroundings create an incentive to exercise, research suggests that an even stronger motivator is destination. When people are excited about where they are headed—like a coffee shop or a friend's house—they are more willing to traverse unfriendly terrain by foot. At the **42nd Annual Meeting of the Canadian Society for Psychomotor Learning and Sport Psychology**, researchers will explore the factors that shape our exercise choices.
Ottawa, Ontario
http://scapps.org

29 Change the structure of a gene, and you change its function. But that is not the only way to alter what a gene does. The emerging field of epigenetics explores how our lifestyle and environment can change gene expression, for example, by adhering molecules such as methyl groups to the DNA strand. **The Behavioral Epigenetics conference**, hosted by the New York Academy of Sciences and the University of Massachusetts Boston, is one of the first to examine how epigenetic changes take place, how they alter behavior, and how they can trigger the onset of disorders such as schizophrenia and depression. [For more about epigenetics, see "The New Genetics of Mental Illness," by Edmund S. Higgins; SCIENTIFIC AMERICAN MIND, June/July 2008.]
Boston
www.nyas.org

30 Although spying on others' intimate acts is a clear violation of privacy, research suggests that voyeurism is quite common. In a 2007 study 74 percent of women and 84 percent of men said they would watch an attractive person disrobe if they wouldn't get caught. **Exposed**, a new exhibit at the San Francisco Museum of Modern Art on display through April 17, 2011, examines how voyeurism pervades our everyday life, focusing particular attention on 19th- and 20th-century photography, celebrity culture and the growth of new surveillance technologies.
San Francisco
www.sfmoma.org/exhibitions/408

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

Roundup: **Curating Creativity**

A colorful concert, a Nobel exhibit and an insightful podcast series reveal the secrets of exceptionally creative minds.

September

11 We've all experienced an "aha!" moment. Although these creative flashes are not well understood, recent research suggests that moments of inspiration coincide with spikes of electrical activity in the brain. **Driven: True Stories of Inspiration**, a podcast series hosted by the San Francisco Exploratorium, investigates the origins and impact of creative insight—and even whether feeling inspired can be contagious.
Available worldwide
http://calendar.exploratorium.edu

Ongoing

What if someone told you that yellow sounds like a trumpet? People who can hear colors or taste shapes have synesthesia—a condition in which the senses are paired in unique ways. Synesthetes often generate innovative visual art, music and theater. To experience the world through a synesthete's eyes, visit the Hayden Planetarium's show, **SonicVision**, where you might see the color of a crescendo or the shape of a B-flat.
New York City
www.amnh.org/programs

Creative thinkers are not simply blessed with genius; they are also incredibly persistent. In 1895 German physicist Wilhelm Conrad Röntgen's obsessive tinkering culminated in his discovery of x-rays and, soon after, a Nobel Prize in Physics. At the Nobel Museum's **Cultures and Creativity** exhibit, viewers can explore the creative processes of Nobel laureates such as Röntgen, Martin Luther King and Ernest Hemingway.
Gamla Stan, Stockholm
www.nobelmuseum.se

Inside the Mind of a Psychopath

Neuroscientists are discovering that some of the most cold-blooded killers aren't bad. They suffer from a brain abnormality that sets them adrift in an emotionless world

By Kent A. Kiehl *and* Joshua W. Buckholtz

The word "psychopath" conjures up movie images of brutal, inexplicable violence: Jack Nicholson chasing his family with an ax in *The Shining* or Anthony Hopkins as Hannibal Lecter, his face locked into an armored mask to keep him from biting people to death. But real life offers another set of images, that of killers making nice: Ted Bundy as law student and aide to the governor of Washington State, and John Wayne Gacy as the Junior Chamber of Commerce's "Man of the Year." Psychopaths are likable guys when they want to be.

Between the two of us, we have interviewed hundreds of prison inmates to assess their mental health. We are trained in spotting psychopaths, but even so, coming face to face with the real article can be electrifying, if also unsettling. One of the most striking peculiarities of psychopaths is that they lack empathy; they are able to shake off as mere tinsel the most universal social obligations. They lie and manipulate yet feel no compunction or regrets—in fact, they don't feel particularly deeply about anything at all.

So much of the way regular people make sense of the world is through emotion. It informs our "gut" decisions, our connections to people and places, our sense of belonging and purpose. It is almost impossible to imagine life without feelings—until you meet a psychopath. But psychopaths often cover up their deficiencies with a ready and engaging charm, so it can take time to realize what you are dealing with.

One of us (Kiehl) used to ask inexperienced graduate students to interview a particularly appealing inmate before acquainting themselves with his criminal history. These budding psychologists would emerge quite certain that such a well-spoken, trustworthy person must have been wrongly imprisoned. Until, that is, they read his file—pimping, drug dealing, fraud, robbery, and on and on—and went back to reinterview him, at which point he would say offhandedly, "Oh, yeah, I didn't want to tell you about all that stuff. That's the old me."

AARON GOODMAN

Although they lack empathy, psychopaths fake normal emotions so convincingly that they often come across as personable, even charming. They learn to compensate for their emotional deficiencies, much the way an amputee manages without the use of a limb.

This appearance of normalcy—the so-called mask of sanity—has bedeviled the study of psychopaths. Though guilty of the most erratic and irresponsible, sometimes destructive and violent behavior, they show none of the classic signs of mental illness. They don't have hallucinations or hear voices. They aren't confused, or anxious, or driven by overwhelming compulsions. Nor do they tend to be socially awkward. They are often of better-than-average intelligence. Add that they do not express true remorse or a desire to change, and it has been easy to view psychopaths not as victims of a dire mental instability but simply as opportunists. To paraphrase the dilemma: Are they mad or simply bad?

From the biblical Cain to the *kunlangeta* of the Yupi Eskimos and the *arankan* of Nigeria, nearly every culture on earth has recorded the existence of individuals whose antisocial behavior threatens community peace. But thanks to technology that captures brain activity in real time, experts are no longer limited to examining psychopaths' aberrant behavior. We can investigate what is happening inside them as they think, make decisions and react to the world around them. And what we find is that far from being merely selfish, psychopaths suffer from a serious biological defect. Their brains process information differently from those of other people. It's as if they have a learning disability that impairs emotional development.

In a collective throwing up of hands, psychiatrists have long written psychopaths off as beyond help. But now that science is unraveling the mechanisms behind the disorder, it's time for that attitude to change. If specific physiological deficits prevent psychopaths from empathizing with others, forming stable relationships and learning from their mistakes, then elucidating them could lead to new treatments: medications, perhaps, or targeted behavioral strategies.

Psychopaths are not merely selfish. Their brains process information differently from those of other people. It's as if they have a learning disability that impairs emotional development.

Kiehl has launched an ambitious multimillion-dollar project—funded by the National Institutes of Mental Health (NIMH) and Drug Abuse (NIDA) and the John D. and Catherine T. MacArthur Foundation—to gather genetic information, brain images and case histories from 1,000 psychopaths and compile it all into a searchable database. To speed the work, Kiehl helped to design a portable scanner—a functional MRI machine housed in a trailer—that can be brought inside prison walls, obviating the need for high-level clearances to bring dangerous prisoners off-site.

We believe psychopaths are as deserving of treatment as anyone with a mental illness, but you don't have to feel sympathy to want to help them. Between 15 and 35 percent of U.S. prisoners are psychopaths. Psychopaths offend earli-

FAST FACTS

Out of Tune with Life

1» Aided by EEGs and brain scans, scientists have discovered that psychopaths possess significant impairments that affect their ability to feel emotions, read other people's cues and learn from their mistakes.

2» These deficiencies may be apparent in children who are as young as five years old.

3» When you tally trials, prison stays and inflicted damage, psychopaths cost us $250 billion to $400 billion a year.

4» Psychopaths have traditionally been considered untreatable, but novel forms of therapy show promise.

PETER SHERRARD *Getty Images*

er, more frequently and more violently than others, and they are four to eight times more likely to commit new crimes on release. In fact, there is a direct correlation between how high people score on the 40-point screening test for psychopathy [*see box on page 28*] and how likely they are to violate parole. Kiehl recently estimated that the expense of prosecuting and incarcerating psychopaths, combined with the costs of the havoc they wreak in others' lives, totals $250 billion to $400 billion a year. No other mental health problem of this size is being so willfully ignored.

Level Heads, Empty Hearts

A man we will call Brad was in prison for a particularly heinous crime. In an interview he described how he had kidnapped a young woman, tied her to a tree, raped her for two days, then slit her throat and left her for dead. He told the story, then concluded with an unforgettable non sequitur. "Do you have a girl?" he asked. "Because I think it's really important to practice the three C's—caring, communication and compassion. That's the secret to a good relationship. I try to practice the three C's in all my relationships." He spoke without hesitation, clearly unaware how bizarre this self-help platitude sounded after his awful confession.

Charming as they may seem, psychopaths can also be tone-deaf because they lack access to their own feelings and those of others. Imagine what it would be like never to be depressed or anxious, never to have regrets or low self-esteem but also never to care deeply for anyone or anything. Psychopaths' emotions are shallow: they feel irritated when they don't get their way and turn to risky behaviors for the flimsiest of reasons. Bereft of loyalties and passions, they wander through life, often straying into criminality on a whim—forgeries, thefts, assaults, even murders may be committed out of some trivial impulse. As for complex emotions such as devotion, guilt or joy, theirs remains a textbook understanding—it has been said that they "know the words but not the music."

Callousness or laserlike focus? Once something has caught their interest, psychopaths have trouble attending to their surroundings.

Dozens of studies reveal that psychopaths experience the world differently from other people. They have trouble making appropriate moral value judgments and putting the brakes on their impulses. They are also hampered in how they respond to emotions, language and distractions—a disconnect that is sometimes seen as early as age five.

Psychopaths are curiously oblivious to emotional cues. In 2002 James Blair of the NIMH showed that they are not good at detecting emotions, especially fear, in another person's voice. They also have trouble identifying fearful facial expressions. And a classic experiment in 1991 co-authored by psychologist Robert D. Hare of the University of British Columbia, a pioneer in the field (and a mentor to Kiehl during graduate school), found that psychopaths miss the emotional nuances of language. The investigators flashed real and nonsense words in front of prisoners, some of whom were psychopaths, and asked them to press a button when they saw a dictionary word. Psychopaths were as quick as nonpsychopaths to differentiate between real and fabricated words. But the experiment went a level deeper, because among the real words some had positive or negative connotations ("milk," "scar") whereas others were neutral ("gate"). For the nonpsychopaths, emotionally charged words leaped off the screen; their automatic brain responses, measured by electroencephalograms, showed a distinctive electrical surge, and they pushed the button faster. Psychopaths did not react faster to emotional words, and their brain waves did not change [*see box on next page*].

Evidence is mounting that language bedevils psychopaths in other ways. Psychopaths have trouble understanding metaphors—for example, they are more likely than others to judge as negative the phrase "Love is an antidote for the world's ills." Additionally, Kiehl found in a 1999 study that psychopaths make more errors when identifying abstract nouns—words such as "love," "deceit," "trust," "dedication" and "curiosity."

Yet another deficiency of psychopaths has to do with how they pay attention. In an ingenious gambling experiment, Joseph P. Newman of the University of Wisconsin–Madison, with whom one of us (Buckholtz) has worked extensively, showed that psychopaths have trouble

(The Authors)

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ROBERT DALY *age Fotostock*

shifting gears, even when their current strategy for obtaining their goal is failing. Participants were given a computerized deck of 100 cards that had been arranged so that nine of the first 10 cards were face cards, eight of the next 10 were face cards, seven of the next 10 were face cards, and so forth. They were told that each time they turned over a card they would receive a point if it was a face card and lose a point if it was not. They could end the game at any time. Players earned easy points at first, but as the odds worsened, nonpsychopaths noticed and stopped playing, usually after about 50 cards. Psychopaths, on the other hand, kept on until the deck was almost finished and their winnings had vanished.

Newman believes that the apparent callousness of psychopaths is actually the result of an attentional quirk: they do not take in new information when their attention is otherwise engaged. Previous research has suggested that psychopaths are unreactive: their palms do not sweat when they are exposed to foul odors or shown images of mutilated faces. But Newman and his colleagues recently demonstrated that psychopaths actually have normal physiological responses to unpleasant stimuli, like the threat of an electric shock—except when their attention is directed elsewhere. Once fixed on a goal, psychopaths proceed as if they can't get off the train until it reaches the station. This narrowly focused, full-speed-ahead tendency, paired with the psychopath's impulsivity, may produce the kind of horror described in *In Cold Blood:* an all-night torture fest that appears almost aimless, the work of two criminals who, having begun the violence, are blind and deaf to information that might halt it (such as a victim's pleas), unable to turn away until it has been completed.

Although "half a teacupful" of his brain leaked onto the floor, Phineas Gage recovered. But there was a change in him. Formerly savvy, even-tempered and responsible, he was now churlish and unpredictable.

An Altered Brain

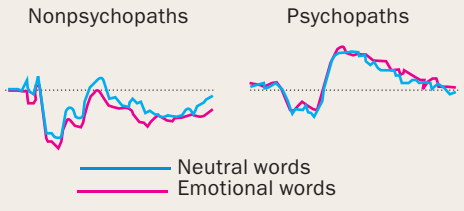
In 1848 a handsome, dark-haired young man named Phineas Gage was working as a construction foreman on the Rutland & Burlington Railroad in Vermont. He and his crew were clearing a rocky area when an accidental explosion blew Gage's tamping iron—a heavy metal rod more than three feet long—through the left side of his face and out the top of his head. Such an injury seemed sure to kill or at the very least cripple him. But although "half a teacupful" of his brain leaked onto the floor, as the attending doctor recalled, Gage apparently never lost consciousness and on his recovery remained relatively fit. His compatriots noticed a change in him, however—one that was more disturbing than if he had lost the use of his limbs. Formerly savvy, even-tempered and responsible, Gage was now churlish and unpredictable, driven by his immediate passions. Gage's story became a classic of neuroscience because it revealed that behavior, which seems a matter of personal will, is fundamentally biological.

Gage lost the use of a part of the brain called the ventromedial prefrontal cortex. Located behind the eyes, this area is structurally similar to its neighbor, the orbitofrontal cortex—which many scientists believe malfunctions in psychopaths. The orbitofrontal cortex is involved in sophisticated decision-making tasks that involve sensitivity to risk, reward and punishment. People whose brains are damaged in this area develop problems with impulsivity and insight and lash out in response to perceived affronts—much like Gage. In fact, such patients are often said to suffer from "acquired psychopathy."

But transformed as Gage was by his accident, he did not show all the charac-

COLLECTION OF JACK AND BEVERLY WILGUS (*Phineas Gage*); "ABNORMAL PROCESSING OF AFFECTIVE WORDS BY PSYCHOPATHS," BY SHERRIE WILLIAMSON ET AL., IN *PSYCHOPHYSIOLOGY*, VOL. 28, NO. 3; 1991 (*EEG*)

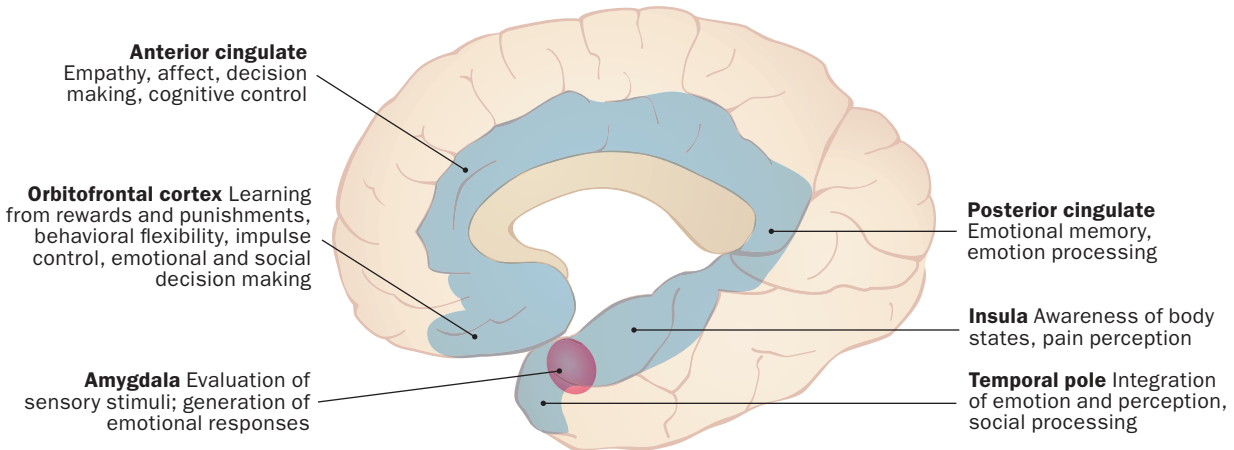
On a Different Wavelength



When shown both real and nonsense words and asked to distinguish between the two, most people are quicker to recognize real words that also happen to be emotionally suggestive, such as "blood." Psychopaths, on the other hand, do not press the button any faster for "blood" than for a neutral word such as "house." Not only that, their EEG readings tend to be consistent no matter what kind of word they are viewing, whereas other people's EEGs change distinctively when they spot an emotional word. Moreover, no matter what kind of word they are viewing, psychopaths have unusually shaped brain waves (*above*). These findings suggest that psychopaths' brains fire differently from those of other people.

A Brain Gone Wrong

A horseshoe-shaped band of tissue nestled in the deepest recesses of the brain may be the area that malfunctions in psychopaths. Known as the paralimbic system, it includes several interconnected brain regions that register feelings and other sensations and assign emotional value to experiences. These brain regions also handle decision making, high-level reasoning, and impulse control. People with brain damage in these areas tend to develop psychopathic traits and behaviors. And imaging studies reveal that in psychopaths, the paralimbic areas tend to be underdeveloped.



SOURCE: "A COGNITIVE NEUROSCIENCE PERSPECTIVE ON PSYCHOPATHY: EVIDENCE FOR PARALIMBIC SYSTEM DYSFUNCTION," BY KENT A. KIEHL, IN *PSYCHIATRY RESEARCH*, VOL. 142; 2006 (*brain*); BALDUR BRAGASON *Nordicphotos/Corbis (finger)*

teristics of psychopathy, such as lack of empathy. This fact suggests that other brain structures are also involved. One likely candidate is the almond-shaped amygdala, which generates emotions such as fear. Monkeys with amygdala damage walk right up to people. Psychopaths, too, are notable for their fearlessness: when confronted with images such as a looming attacker or a weapon aimed their way, they literally don't blink.

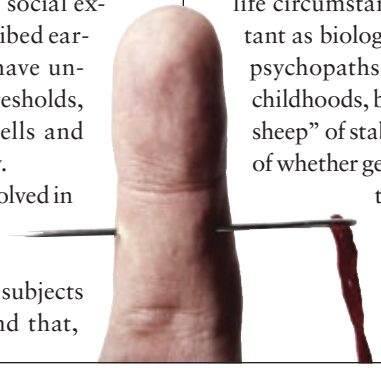
But evidence suggests that one or two brain areas are not enough to produce the profound impairments of psychopaths. Kiehl recently proposed that psychopathy emanates from the paralimbic system, a group of interconnected brain structures that are involved in emotion processing, goal seeking, motivation and self-control [*see box above*]. Supporting this hypothesis are fMRI images of psychopaths' brains made by Kiehl and others, which show a pronounced thinning of the paralimbic tissue—indicating that this part of the brain is underdeveloped, like a weak muscle.

In addition to the orbitofrontal cortex and amygdala, the paralimbic system includes the anterior cingulate cortex and the insula. The anterior cingulate regulates emotional states and helps people control their impulses and monitor their behavior for mistakes.

The insula plays a key role in recognizing violations of social norms, as well as in experiencing anger, fear, empathy and disgust. Psychopathic behavior is by definition insensitive to social expectations, and as described earlier, psychopaths can have unusually high disgust thresholds, tolerating repellent smells and images with equanimity.

The insula is also involved in pain perception. Studies of psychopaths—including one in which subjects got electric shocks—find that, under certain conditions, they are strikingly unfazed by the threat of pain; they also have trouble noticing their errors and adjusting their behavior accordingly (which helps to explain the self-defeating way that psychopaths land in jail repeatedly, unable to learn from past mistakes).

Are psychopaths made or born? The answer is probably both. If, as investigators believe, genes account for 50 percent of the variability among those who exhibit adult antisocial traits, that means life circumstances are just as important as biological inheritance. Some psychopaths are scarred by rough childhoods, but others are the "black sheep" of stable families. Regardless of whether genes or environment has the greater influence,



Not only are psychopaths blithe about inflicting pain, they often don't fear it.

early intervention—perhaps even in preschool—could be critical. Just as there is a moment in childhood when the brain is primed to learn language, a task that becomes much harder later on, we suspect there may be an early window for developing the social and cognitive skills that underlie what we call "conscience."

Ignored at Our Peril

Psychopaths are misunderstood. This fact may not tug at the heartstrings, but it is a problem for all of us. Some researchers have estimated that as many as 500,000 psychopaths inhabit the U.S. prison system, and there may be another 250,000 more living freely—perhaps not committing serious crimes but still taking advantage of those around them. Helping them manage their impulsivity and aggression could protect many innocents. Until now, though, few efforts have been made in that direction. Billions of research dollars have been spent on depression; probably less than a million has been spent to find treatments for psychopathy. In part, psychologists have been turned off by evidence that psychopaths are untreatable. For example, some studies show that after receiving group therapy in prison, psychopaths are *more* likely to commit new crimes than if they had received no treatment at all. Listening to others bare their soul is clearly not a good strategy: psychopaths are notoriously good at learning and exploiting the weaknesses of others. They also have trouble absorbing abstract ideas, so lectures about personal responsibility are unlikely to penetrate.

But there is room for optimism: a new treatment for intractable juvenile offenders with psychopathic tendencies has had tremendous success. Michael Caldwell, a psychologist at the Mendota Juvenile Treatment Center in Madison, Wis., uses intensive one-on-one therapy known as decompression aimed at ending the vicious cycle in which punishment for bad behavior inspires more bad behavior, which is in turn punished. Over time, the incarcerated youths in Caldwell's program act out less frequently and become able to participate in standard rehabilitation services.

A group of more than 150 youths treated by Caldwell were 50 percent less likely to engage in violent crime afterward than a comparable group who were treated at regular juvenile corrections facilities. The young people in the regular system killed 16 people in the first four years after their release; those in

Do You Know a Psychopath?

Chances are, you have met a psychopath. People with the disorder make up 0.5 to 1 percent of the general population. When you discount children, women (for reasons that remain a puzzle, few women are afflicted), and those who are already locked up, that translates to approximately 250,000 psychopaths living freely in the U.S.

How can you recognize a psychopath? The test that experts use, known as the Hare Psychopathy Checklist–Revised, consists of 20 criteria, each of which is scored as a 0, 1 or 2. The criteria include behaviors and traits such as pathological lying, proneness to boredom and sexual promiscuity (*below*), which are assessed during an interview as well as by consulting prison and police reports and other official records. The highest possible score is 40 (a score of 2 on all 20 criteria), but anyone who gets 30 or higher is considered a psychopath.

The thing is, everyone falls somewhere on the psychopathy continuum. The average person scores about a 4, but there are plenty who rank in the teens and 20s—not high enough to receive an official diagnosis yet possessing significant (and often noticeable) psychopathic tendencies—the bullying boss, the drifter, the irresponsible guy who is always milking the generosity of friends and lovers.

Antisocial Behavior

- Need for stimulation and proneness to boredom
- Parasitic lifestyle
- Poor behavioral control
- Sexual promiscuity
- Lack of realistic long-term goals
- Impulsivity
- Irresponsibility
- Early behavior problems
- Juvenile delinquency
- Parole or probation violations

Emotional/Interpersonal Traits

- Glibness and superficial charm
- Grandiose sense of self-worth
- Pathological lying
- Conning and manipulativeness
- Lack of remorse or guilt
- Shallow affect
- Callousness and lack of empathy
- Failure to accept responsibility for own actions

Other Factors

- Committing a wide variety of crimes
- Having many short-term marital relationships

Psychopaths typically get worse, not better, after standard treatments like group therapy. Insights into others' vulnerabilities become opportunities to hone their manipulation skills.

Caldwell's program killed no one. The economic benefits are also huge: for every $10,000 society spends on treatment, we save $70,000 that would have been required to keep those people in jail.

The ongoing brain and genetic studies are likely to further improve Caldwell's results: perhaps, as with depression, a combination of therapy and medication will prove especially potent. But such advances are slowed by the fact that psychopathy is often overlooked by the mental health mainstream. It isn't even included in the *Diagnostic* and *Statistical Manual of Mental Disorders*—the *DSM*—an exhaustive catalogue of more than 300 known psychiatric conditions that serves as the clinician's bible. The *DSM*'s framers instead created a catchall diagnosis for the criminally inclined, known as antisocial personality disorder, and left it at that.

Why was psychopathy excluded? The creators of the *DSM* may have felt that it would be too difficult for the average therapist to make an accurate diagnosis: after all, psychopaths are sure to lie convincingly during the interview.

Whatever the reasons, many psychiatrists are left with the false impression that psychopathy and antisocial personality disorder are the same. They are not. Antisocial personality disorder is a helpful diagnosis when the question is whether a person is likely to behave badly, but it does nothing to discriminate among criminals. Only one in five people with antisocial personality disorder is a psychopath. Yet time and again at trial, experts wrongfully attest that when a defendant has antisocial personality disorder, it means he is a psychopath, which in turn means he is likely to reoffend and should not be paroled.

> For every $10,000 spent on decompression therapy, a promising treatment for youths with psychopathic tendencies, we save $70,000 that would have been required to keep them in jail.

As scientists continue to describe the brain dysfunctions of psychopaths, the revelations promise not only to aid disturbed individuals but to bring sanity to society. For it is senseless to ignore psychopaths when they pose such a threat. When lawyers, jailers, psychiatrists and others begin to see psychopaths for what they are—not monsters but people whose emotional disabilities may cause them to act monstrously—we will all be on the path to a safer future. **M**

(Further Reading)

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CORBIS

Cubicle, **Sweet** Cubicle

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Why some office spaces alienate workers, while others make them happier and more efficient

By S. Alexander Haslam and Craig Knight

Once upon a time the factory, with its dirty, noisy machinery, was the standard workplace of industrialized nations; today it's the office. Hundreds of millions of people—at least 15 percent of the population in developed countries—work at a desk, with or without a partition that separates them from the desks of their co-workers. That's an awful lot of swivel chairs.

But a cubicle is more than a mere physical workspace. In recent years social and organizational psychologists have begun to amass evidence that the character of people's personal work environments affects their performance in profound and surprising ways. The size of our desks, our proximity to natural light, the quality of the air we breathe and our privacy (or lack thereof)—all are major predictors of our comfort, our contentment and our productivity.

We have found in our experiments, for instance, that when well-meaning employers hang art posters and provide potted plants to brighten the atmosphere, their efforts can backfire, creating environments that are as discouraging to workers as sterile ones and that inspire the same level of disaffection. Employees perform best when they are encouraged to decorate their surroundings as they see fit, with plants and ornaments, comic calendars, photographs of their children or their cats—whatever makes them feel most comfortable and in their element.

Not only does office design determine whether or not people's backs ache, it influences how much they accomplish, how much initiative they take and their overall professional satisfaction. Employers rarely consider these psychological ramifications—but they should, because paying more attention to workspace design can boost employees' well-being and productivity at minimal cost.

A Very Short History of Office Design

The origins of the modern office can be traced back to the medieval scribes who were entrusted with keeping church and government records. These skilled artisans worked in the homes of kings and noblemen, painstakingly writing and copying documents by hand. Becoming a scribe required education beyond the reach of most citizens, so scribes were regarded as a privileged class. They were often allowed to set up the small rooms where they worked however they liked, typically with a motley assortment of chairs, stools, books and drafting tables.

MATT KENYON *Ikon Images/Getty Images*

> At some companies, employees have free rein to deck out their cubicles. But at others, managers put up posters with sayings like: "Attitude is a little thing that makes a big difference."

By the end of the industrial revolution, this picture began to change. As the ranks of the professional class swelled, so did the number of supervisors tasked with overseeing their labor. This development drove the demand for standardized workplaces in which managers had greater control over their clerical workforce and were able to keep an eye on underlings' progress at all times.

In the early 20th century Pennsylvania engineer Frederick W. Taylor pioneered what became known as the scientific management movement. For Taylor, the core task of management was to discover and implement the "one best way" to do any particular job. In 1911 he wrote *The Principles of Scientific Management*, a book so influential that people began to speak of firms that had been optimized for productivity as having been "Taylorized." Everything should be removed from a given workspace, Taylor recommended, except the materials absolutely needed to do the job at hand. Whereas much of Taylor's analysis pertained to jobs in industry and the assembly line, employers soon began to apply his ideas to white-collar and creative workspaces as well.

White-collar workers everywhere are familiar with the open-plan office—a sterile space intended to accommodate, or "warehouse," large numbers of employees at clusters of desks separated by flimsy partitions that offer a bare modicum of privacy. Such spaces can be quickly modified in response to hirings, firings or fluctuating work assignments. Some organizations even go so far as to practice "hot desking," allocating space on a first-come, first-served basis so that no one is guaranteed the same desk from one day to the next. In such environments, any form of clutter—particularly mess created by employees themselves—is viewed as an impediment to productivity.

The open-plan setup enables supervisors to subtly monitor what their subordinates are doing. Anyone who has had

FAST FACTS

Feng Shui at the Office

1» **In the modern office, many desks are often crammed into a wide-open space possessing few interior walls. This layout was designed for flexibility and to enable bosses to keep an eye on subordinates.**

2» **Studies show that employees are happiest and most productive when they control the look and style of their work areas.**

3» **Recent research indicates that even apparent bonuses such as comfy hang-out rooms and luxurious decor can alienate workers when they are imposed by management without genuine consultation.**

to walk past his boss's desk to get to (or leave) his own or whose computer is positioned in such a way that she knows her manager could appear at any moment and, peering over her shoulder, see exactly what she is doing will find it interesting to learn that the designers of open-plan workplaces borrowed from a concept called the Panopticon. Developed in 1785 by utilitarian philosopher Jeremy Bentham, this circular prison featured a central tower from which guards could monitor the inmates without themselves being seen. This was an efficient form of control in that a small number of jailers could keep all the prisoners on edge; the inmates would never know when they were or were not being observed.

Of Legos and Lightsabers

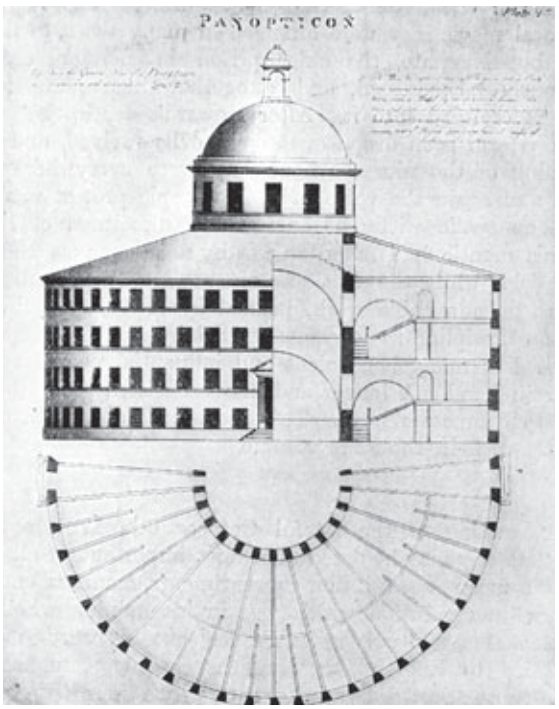
The 1990s dot-com boom—the proliferation of well-funded startups and more established digital media firms, all vying to woo skilled workers—popularized an alternative to the open-plan office. Along with cappuccino bars, air hockey tables and Aeron chairs, bold and invigorating visual elements carried the day—huge tropical fish tanks and dramatic works of art—resulting in attention-grabbing and sumptuous environments. The idea was to make workers feel valued, to win their loyalty and to encourage them to spend extra hours at their desks. At the Google "campus"—the word itself signals a distancing from traditional workplace dynamics—in Mountain View, Calif., and at game companies, interactive advertising agencies, and other entrepreneurial white-collar firms, workers have free rein to deck out their cubicles with lightsabers, vintage lunch boxes, Hello Kitty memorabilia or masterpieces built of Legos—anything beautiful, fun or personally meaningful. Employees compete to see who can devise the most unique and appealing workspace.

But at other companies, managers take a top-down approach to workspace enrichment, bedecking cubicles in "Successories" posters ("Attitude is a little thing that makes a big difference") and creating "synthetic fun" with, for example, fake dens stocked with beat-up sofas and a fridge full of beer.

Enriched offices are widely thought to increase employees' well-being and productivity. But they do not always yield dramatic upswings in productivity. In 2009, for instance, scientists at the University of Amsterdam replaced traditional offices with an enriched open-plan office design in which spaces were set aside for specific work functions (a "cockpit" for tasks demanding concentration and a "living room" for social interaction with colleagues). Despite these innovative extras, the quantity of work the employees performed actually decreased slightly after they had been in the new office space for six months. Why would this be?

We recently carried out two experiments to study the effect of the office environment on productivity. We conducted one study in a psychology laboratory and the other with real workers in a commercial office in London. In both studies, we asked participants to perform an hour's worth of office tasks (checking documents and processing memos, for example) in one of four kinds of office space [*see box on next page*].

The "lean" office was a sanitized-looking space containing only the items necessary to perform the tasks: a pencil, paper, a bare desk and a swivel chair. The "enriched" office had these basic supplies but was decorated with plants and art, including several large, bright Georgia O'Keeffe–style pictures. In the "empowered" office, participants were provided the same plants and art that were in the enriched office but were allowed to arrange them however they chose or not use them at all. Finally, in the "disempowered" office, participants were given the opportunity to decorate, but when they had finished doing so, the experimenter rearranged the office so that it matched the enriched condition.



The modern office is based in part on an 18th-century prison design, the Panopticon. A round building full of cells encircles a courtyard with a central tower, from which a few guards efficiently monitor the inmates. Sound familiar?

This last scenario may not seem to have real-life relevance, but in fact office workers have to cope surprisingly often with this kind of interference. We recently interviewed an IT manager at a large bank in Sydney, Australia, whose office arrangements and decor have been changed by senior management no fewer

(The Authors)

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TIME & LIFE PICTURES/GETTY IMAGES

than 36 times over the past four years. "I feel like a pawn on a chessboard, and everyone in my office feels the same," he said. "It's one of the main things we talk about: 'What are they planning to do to us next?' To be frank, it's not a lot of fun, and we all find it incredibly stressful."

Our studies, published in the June issue of the *Journal of Experimental Psychology: Applied,* found that while an attractive environment increases worker productivity, even more critical is employee autonomy. People in the enriched office worked about 15 percent faster than those in the lean office, with no more errors, and they reported fewer health-related environmental complaints. "The pictures and plants really cheered up the place" was a typical reaction to the enriched office, while one participant said of the lean office, "It just felt like a show space with nothing out of place. You couldn't relax in it." Productivity and well-being increased even further—by around 30 percent—in the office that participants customized themselves. "That was smashing; [I] really enjoyed it. What a fantastic office. When can I move in?" one subject gushed. Yet when employees' personal choices were overridden, their performance and well-being dropped to the same levels they showed in the lean office. "I felt really undermined," one of the workers in the disempowered office reported. "I'd spent ages arranging the room." Another told the experimenter, "I wanted to hit you."

An IT manager at a bank in Sydney, Australia, told us that senior managers had rearranged his office decor 36 times over the past four years. "I feel like a pawn on a chessboard," he complained.

Control Issues

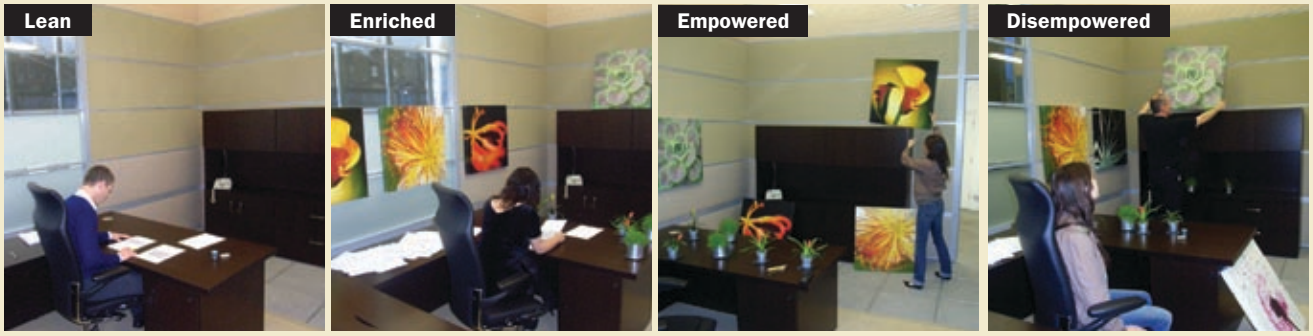
Factors other than the design and trappings of a workspace, such as acoustics, can also affect employee performance. A study in 2009 at the University of Turku in Finland evaluated how well workers did on cognitive tasks in a range of different sound environments. The team found that when workers heard irrelevant speech sounds nearby (think: the NPR broadcast drifting over from a colleague's cube), their performance on reading comprehension and number-recall tasks declined, as did their reported comfort. The researchers speculate that extraneous speech may disrupt working memory and prompt stress responses and recommend high cubicle walls and sound-absorbing wall materials to address the problem.

Showing employees how to manipulate work environments to their own advantage, on the other hand, has distinct benefits. In a 2009 study by the Liberty Mutual Research Institute for Safety in Hopkinton, Mass., researchers evaluated the effects of giving workers an ergonomics training course and supplying them with highly adjustable office chairs. Those who received the training and chair not only had a lower risk for musculoskeletal problems, they reported feeling better about their work situation in general.

Indeed, granting or withholding control over employees' working conditions has significant implications for health and well-being, as evidenced by studies exploring what is often called sick build-

Trading Spaces

To investigate how the look of a cubicle influences the work that gets done there, the authors asked people to do tasks in four environments. The "lean" office contained only essential equipment. The "enriched" office was decorated with plants and art. In the "empowered" office, people had the freedom to arrange the plants and art as they chose. In the "disempowered" office, the experimenter undid these personal touches. The "empowered" office workers were the most content and productive by far.



CRAIG KNIGHT

GETTY IMAGES

ing syndrome. Symptoms include irritation to the eyes, nose, throat and skin, as well as fatigue, nausea, headaches and dizziness. The syndrome is usually attributed to physical properties of the building, such as problems with the ventilation, heating or air-conditioning systems. But in 1989 a major survey at the University of Copenhagen challenged that notion. The researchers found that complaints of sick building syndrome are around twice as common among workers who have junior positions and hence exert little control over their work environments.

The relation between lack of workspace control and sick building symptoms holds true even in "employee-friendly" enriched environments like that of a U.K.-based travel company, according to research by Chris Baldry, a management professor at the University of Stirling in Scotland. On the surface, the work environment looked engaging—brightly colored workspaces were festooned with plastic palm trees. But a Panopticon-style zone called Mission Control allowed managers to clandestinely monitor employees at all times, and workers continually complained of physical ailments such as dry coughs.

Feelings of control are also linked to productivity. A 2010 study at Chung-Ang University in Seoul surveyed nearly 400 workers at Michigan companies and found a relation between employees' perceived control over their work environments and their ability to focus. In this study, "control" was defined, in part, as being able to move furniture around inside the workspace and customize displays, similar to our empowered office condition. Survey responses indicated that when workers felt they had a say in the physical aspects of their workspace, the negative effects of noise and other distractions were reduced.

Why are people who work in spaces to which they feel a personal connection happier and more productive—even healthier? We think that when people feel uncomfortable in their surroundings they are less engaged—not only with the space but with the work they perform in that space. Arranging offices in ways that ignore employees' preferences and individuality can undermine production and focus, even if well-meaning planners intend the opposite. When employees get to surround themselves with personally meaningful objects at work, the efficiency gurus, enrichment experts and plastic palm-tree peddlers can all stay home. M

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SPECIAL REPORT

Physical Education

There has been a lot of talk about what is broken in the U.S. education system and why American students lag behind Europeans and Asians. But in this back-to-school special section we highlight solutions: elegant research suggesting simple—and surprising—ways to nurture academic achievement.

The theme of these three articles: Actions shape thoughts. It turns out that touch, movement and gestures are critical to learning. And why not? From our beginnings as toe-nibbling infants, we experience the world through our bodies as well as our brains, and the more integration between the two, the better.

Children who construct sophisticated block towers in preschool go on to score higher on high school math tests [see "The World at Our Fingertips," at right]. And contrary to reigning stereotypes, physically fit youngsters are more likely than their nerdly counterparts to get good grades [see "Smart Jocks," page 42]. Meanwhile gesticulating, too, aids intellectual and problem-solving abilities [see "Hands in the Air," page 48].

Enough said. For your own take on how doing promotes learning, start turning these pages.

ZIGY KALUZNY Getty Images

The WORLD at Our Fingertips

The sense of touch helps children to ground abstract ideas in concrete experiences

By Derek Cabrera and Laura Colosi

One evening while one of us (Colosi) was making dinner, her six-year-old daughter, Gianna, appeared with 10 little pieces of paper in her hand. She had been doing her homework, she said, and each of the scraps contained one of the words she was supposed to learn. When her mother asked why Gianna had torn apart her spelling list, she shrugged: "So I can do stuff with it." For Gianna, abstract concepts became easier to understand after she had transformed them into physical objects—in this case, pieces of paper she could hold, feel and manipulate.

The connection between touch and understanding is deeply instinctual, beginning in infancy and continuing, in varying forms, throughout our lives. Experiments have found that touch is as important as vision for learning and retaining information. Studies also show that tactile activities such as playing with blocks help children improve everything from their math abilities to their thinking skills. We are knowledge architects, building intellectual edifices through physical experiences.

Yet many school curricula are based on the old paradigm that

Long before a baby understands language, touch enables learning. When infants grab and knead their own limbs, they are trying to discover what is part of their own bodies and what is external.

knowledge flows from an expert instructor to a passive student. This mode of teaching is especially evident after children leave kindergarten for the long trek through elementary, middle and high school, where instruction relies less on hands-on exploration and more on rote memorization designed to improve test results. In contrast, haptics—the study of how the sense of touch affects the way people interact with the world—suggests that if educators engaged all of their students' senses, the children would not only learn better, they would think better, too.

The mind-expanding potential of haptic learning is not just for kids. LEGO, the Danish toy manufacturer, is marketing a training program called Serious Play to corporate clients. Teams of employees build LEGO models and use them to enact business scenarios—a corporate takeover, say—to spark new ideas and foster esprit de corps. The inspiration for LEGO's program, according to the company's Web site? Plato, who famously wrote: "You can discover more about a person in an hour of play than in a year of conversation." You may be able to learn more about the world, too.

FAST FACTS

To Touch Is to Think

1» Learning through touch is instinctual. Even newborns can recognize objects by touch alone.

2» At first, tactile learning involves manipulating objects. But as children mature, they begin to apply these physical concepts to abstract ideas.

3» Hands-on exploration helps children learn more and remember what they have discovered. It also enhances math, verbal and thinking skills.

The Play Instinct

For children, play is second nature—no life coach required. It is, indeed, the child's way of being. Even the youngest infants experiment with touch and movement to figure out what belongs to them and what to their environment. Every parent has watched their wriggling baby test the body's limits, kicking legs, flapping arms and twisting appendages with gusto.

The notion that play has deeper value than diversion is not new [see "The Serious Need for Play," by Melinda Wenner; Scientific American Mind, February/March 2009]. As early as 1693, philosopher John Locke proposed helping children learn language through "dice and play-things, with the letters on them to teach children the alphabet by playing." In the 19th century German educator Friedrich Froebel argued that integrating play into educational settings would engage children and foster a long-term interest in learning, contradicting the belief, widely held at the time, that children younger than seven could not be taught because of their short attention spans. Froebel created blocks known as "Froebel gifts" to help students learn through hands-on play. He is considered the father of kindergarten.

In the 1960s Swiss developmental psychologist Jean Piaget posited that play is how children make sense of the world and acquire the skills they will need to negotiate adult life. Piaget found that in-

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Children who had played the most with blocks in preschool had **higher math scores** in seventh grade.

fants and children until the age of seven learn primarily through imitation, play and object manipulation; they first develop their reflexes and hand-eye coordination and experiment with spatial abilities, and later they use images and words to represent objects so they can classify them. Older children develop logic and reasoning skills by manipulating objects and sorting them—from smallest to largest, say—mastering such concepts as scale, quantity and length. As one Piaget acolyte, Massachusetts Institute of Technology professor Seymour Papert, put it, "Better learning will not come from finding better ways for the teacher to instruct, but from giving the learner better opportunities to construct."

Grasping the Curriculum

A myriad of so-called manipulatives (standardized versions of Gianna's little pieces of paper) fill preschool classrooms—wooden blocks, math beads, coins, letters made of sandpaper—and for good reason. Haptic feedback can help children retain information and hone their academic skills.

In 2006 science education professor M. Gail Jones of North Carolina State University and her colleagues had 36 middle and high school science students conduct nanoscale experiments on a simulated virus, measuring, pushing, cutting and poking the organism. One group of students could "feel" the virus through a haptic gaming joystick attached to their microscopes. The other group used a mouse instead of a joystick to move the organism under the microscope, receiving visual feedback only. After the lesson, the students filled out a questionnaire to measure their knowledge. The students who received haptic feedback recalled a greater number of viral characteristics and found the lesson more interesting.

Touching and manipulating objects also promotes the symbolic thinking essential to learning language and mathematics. In a 16-year longitudinal study published in 2001, educational theorist Charles H. Wolfgang of Florida State University followed 37 preschool children as they played with blocks. When the study began, Wolfgang and his team let the children, then four years old, play freely and encouraged them to use as many blocks as possible. Over the years Wolfgang followed the students' progress, tabulating their scores on the California Achievement Test in third, fifth and seventh grades, their enrollment in math classes and advanced courses, and their high school grade-point average. He then correlated the sophistication of each student's early block play with their test scores in middle and high school mathematics. The children who had played the most with blocks in preschool had significantly higher standardized math scores in seventh grade and high school than their peers did.

Toddlers quickly learn to distinguish balls from cubes and other shapes (*below*). That sorting ability grows more sophisticated with age (*left*) and forms the basis for making abstract distinctions—for example, among various shades of unethical behavior.

Based on the research he has conducted during the past 15 years, one of us (Cabrera) has concluded that hands-on exploration also contributes to four critical thinking skills essential to learning: making distinctions, recognizing relationships, organizing systems and taking multiple perspectives. At first, this learning involves objects—hence the importance of touch. But as children mature, they begin to apply these concepts—which they have quite literally grasped—to ideas.

This or That?

One of the critical lessons children glean from hands-on play is how to distinguish one object from another. Human beings are constantly called on to discriminate among words, locations, concepts, objects and life-forms with varying degrees of specificity. Indeed, this skill is critical: if children could not, for example, tell the difference between the many va-

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ALEX SLOBODKIN *iStockphoto (numbered blocks)*; BETSIE VAN DER MEER *Corbis (child with berries)*; AGE FOTOSTOCK *(shape sorter)*

If children could not distinguish between berries, they would not know **food from poison**.

rieties of berries and mushrooms, they would not know which are food and which are poison. In a 1997 study psychologist Laura Namy, then at Northwestern University, and her colleagues observed that very young children classify and sort objects. In the experiments, babies between the ages of 16 months and 21 months played with balls, cubes and a box with a hole that would admit only the balls. The babies quickly learned to differentiate between the two object types, pushing the balls through the round opening and leaving the cubes aside.

A talent for discrimination by touch is apparent even in newborns. In a 2005 review of her experimental work with infants, psychologist Arlette Streri of Paris Descartes University reported that just 16 hours after birth, babies could recognize an object using touch alone, even when encountering it again at a different angle.

Tactile exploration enhances reasoning skills. When stacking coins, for example, children learn that two piles of equal value may look quite different from each other.

Researchers had the newborns handle several geometric shapes and measured how much time they spent exploring each one. The babies spent less time with objects they had touched before, suggesting that they already knew them and could recognize them from their contours. In other words, the infants could interpret an object's shape from multiple perspectives—a precursor of the adult ability to understand the world from the perspectives of different people. Even at an extremely young age and before the development of language, children can spontaneously discriminate among objects.

Touch helps older children sharpen these abilities when the time comes to draw more abstract distinctions—not only between, say, mammals and reptiles but between a horse and a zebra. In a 2006 study of prekindergarteners through third graders, psychologists Karyn Wellhousen and Rebecca Giles of the College of Education at the University of South Alabama observed that children who frequently played with blocks were more likely to participate in tasks involving the use of symbols such as letters and numbers. The block players also built larger vocabularies, which was evident when they described their structures to their playmates and teachers.

Connecting the Dots

Touch can also help children discern relationships, a critical skill in many areas of life. Italian physician and educator Maria Montessori, who observed that thinking is "expressed by the hands before it can be put into words," used many materials in her schools to demonstrate relationships of scale. One was the pink tower, in which children stack graduated pink wooden cubes into a tapering structure. As they handle and place the cubes, the children come to understand how the size of each piece relates to its position within the whole. Montessori schools also highlight the relationship between part and whole by giving students pie pieces to help them work with fractions. In every case, fitting the pieces together in the right way solves the problem.

Parents can improvise such lessons at home. Cabrera's son, Carter, was baffled by his early encounters with mathematics. So the two gathered a pile of Cheerios and sat down to play. It was a great help to Carter to count out three Os and hold them in his hand, then place them within a larger object (a small bowl) that represented the unit of three. Thus, he discovered the relationship between unity (a bowl containing three Cheerios) and quantity (three individual Cheerios): they have equal value, but they are not the same. That was no small achievement—this simple understanding serves as the basis of all algebra and the concept of variables.

As their knowledge of relationships grows, children come to see that the world consists not just of objects but of systems made up of parts. Early on, children learn that their bodies consist of a head, torso, legs and arms and that their heads, in turn, have eyes, ears, nose, mouth and brain. Over time they master increasingly complex systems, from the three atoms of a water molecule to an ecosystem composed of dirt, air, water, trees and animals.

Touch can help children organize systems as

KIM TAYLOR *DK Images/Getty Images (berries)*; AGE FOTOSTOCK *(counting coins)*

well as understand them—the goal being to foster minds that can synthesize information as well as break it into its component parts. In a 2006 experiment led by elementary education professor James Minogue of North Carolina State University, middle school science students who received haptic feedback through a stylus as they designed a virtual animal cell—letting them feel shape, size, texture, viscosity, elasticity and resistance to motion as they arranged the cell's organelles—did a slightly better job at organizing their cell than did students who received no haptic feedback. But the positive effect was especially strong among students who did not know much about cell structure before the experiment.

Other People's Shoes

Once children understand how objects relate to one another, their imaginations are primed to consider the world from different perspectives—whether that means interpreting the Civil War from both the Northern and Southern standpoints or settling a playground quarrel. Learning to see things from various points of view is an important skill. It enhances the intellect by pushing us to challenge our assumptions and builds social skills by encouraging emotional intelligence, empathy and compassion.

Although perspective is a visual metaphor, it can be achieved through touch alone. In a 2010 study led by neuroscientist Ryo Kitada of Japan's National Institute of Physiological Sciences, researchers placed a plastic hand on a table in front of an adult volunteer—a right or a left hand, palm up or down, pointing in any direction. The volunteer then had to indicate as quickly as possible the side of the body to which the hand belonged by depressing a pedal with his or her left or right foot. In some cases, the subjects were asked to imagine the hand was their own, in others that it was the hand of someone seated opposite. Sometimes the volunteers could see the hand but not touch it, and in other trials they touched it blind. The response times were just as quick and accurate when the participants used touch alone to identify the hand as when they used only sight, even when they were meant to imagine the hand on another person's body.

For children, touch provides a visceral understanding of multiple perspectives. As the infant studies showed, sorting objects by size, color or shape is an early touch-based introduction to point of view. So is make-believe: when children use puppets, dolls or dress-up to create imagined scenarios, they learn to see the world from another vantage point. In research conducted in Austin in 1993, education specialist Stuart Reifel of the University of Texas and June Yeatman, a nursery school teacher, recorded four- and five-year-olds talking with one another as they played with various objects, toys and art supplies. After analyzing the conversations, Reifel concluded that children routinely take on different personas, switching frequently from one character to the next. This sort of fantasy role-playing, he believes, lets children try out new personalities, adopting the perspective of each in turn.

By helping children build mental constructs of the complex web of relationships among objects, ideas and people, the sense of touch prepares them to approach any problem—even the most challenging and sophisticated ones. Listen to Nobel Prize winner James D. Watson describe how he and Francis Crick discovered the structure of DNA. "In place of pencil and paper, the main working tools were molecular models superficially resembling the toys of preschool children," he said. "All we had to do was construct a set of models and begin to play." M

AGE FOTOSTOCK

Fantasy play is a hands-on way to imagine what it feels like to be somebody, or something, else. Make-believe helps children develop tolerance and empathy and a respect for diverse points of view.

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SPECIAL REPORT
Physical Education

SMART JOCKS

When kids exercise, they boost brainpower as well as brawn

By Steve Ayan

Despite frequent reports that regular exercise benefits the adult brain, when it comes to schoolchildren, the concept of the dumb jock persists. The star quarterback stands in stark contrast to the math-team champion. After all, the two types require seemingly disparate talents: physical prowess versus intellect. Letting kids run around or throw a ball seems, at best, tangential to the real work of learning and, at worst, a distraction from it.

Parents, teachers and education policy makers have pitted athletics against academics even as they trumpet exercise as an antidote to obesity and poor health. From preschool onward, teachers encourage children to sit still rather than scamper. Many schools have cut back on physical education to make room for the three R's. And when student scores on standardized tests become of primary importance to parents, politicians or other stakeholders in the education system, educators may feel pressured to direct students toward academic pursuits and away from athletic ones.

But accumulating evidence strongly suggests that such thinking is wrongheaded. Time spent horsing around outdoors or playing on sports teams can help kids concentrate and improve their performance in the classroom. Recent studies have linked students' cognitive performance with measures of physical fitness such as aerobic capacity—the ability of the heart, lungs and blood vessels to cope with intense exercise—and body mass index (BMI), a metric that relates body weight to height. What is more, enrolling kids in exercise programs appears to help them excel academically. Investigators are also revealing how exercise expands the mind, by fostering the formation of new connections between brain cells.

From Agility to Ability

In adults, regular aerobic exercise is associated with improved intellectual abilities and, as time goes on, a lower rate of cognitive decline and a diminished risk of dementia [see "Fit Body, Fit Mind?" by Christopher Hertzog, Arthur F. Kramer, Robert S. Wilson and Ulman Lindenberger; Scientific American Mind, July/August 2009]. And developmental psy-

Being fit at age 18 was correlated with a higher level of **scholarly achievement** in later life.

chologists have long suggested that in young children there is a link between physical and mental growth. Early in life, agility leads to ability: by manipulating objects such as light switches and zippers, two- to five-year-olds develop a real-world knowledge base. For example, a child who builds with blocks or uses simple tools gains experience with the basic laws of physics: when the blocks are stacked askew, she learns, her tower crumbles; if he lets go of a hammer, he discovers, it can bruise his foot.

Small-scale movement fuels mental growth in children. Building with blocks, for instance, provides experience with the basic laws of physics.

But although the cognitive benefits of manipulating toys and tools are well known, only in the past decade have scientists begun uncovering a link between more vigorous physical activity and intellect in children. In 2008 psychologist Charles H. Hillman of the University of Illinois and his colleagues examined research results on exercise and cognition from studies dating back to the 1990s. Their review included about a dozen investigations of children and teenagers, most of which showed that higher levels of aerobic fitness—but not muscle strength or flexibility—were associated with better performance on standardized tests and in school. In other words, the more physically fit the young person, the more likely he or she is to get good grades—a connection that holds from elementary school all the way through college.

For example, in 2007 a team led by education researcher Darla M. Castelli, also then at Illinois, assessed the physical fitness of 259 third- and fifth-grade students by measuring each child's BMI and by giving each of them a running exam and a test of muscle strength. The investigators found that a child's average performance on math and reading tests was directly related to his or her aerobic capacity—that is, the distance they could run.

Bolstering the link between physical and academic fitness, neuroscientist Hans-Georg Kuhn of the University of Gothenburg in Sweden and his colleagues recently discovered a relation between aerobic capacity and IQ in young adults. In a study published in November 2009, the scientists reviewed the scores of more than one million men on the physical-fitness and intelligence tests that they took when they enlisted in the military at age 18. Again the results indicated that cardiovascular fitness, but not muscle strength, was associated with overall intelligence. And after scouring other national databases, the researchers found that being physically fit at age 18 was correlated with a higher level of scholarly achievement in later life.

In May 2010 physiologist Christian Roberts of the University of California, Los Angeles, and his colleagues reported additional support for the idea that aerobic conditioning and academic success go hand in hand. The investigators tested the athletic proficiency of 1,989 fifth, seventh and ninth graders attending California schools by timing how fast they could run (or walk) a mile and measuring their BMIs; the investigators then correlated these fitness measures with the students' standardized test scores. They found that the students whose run/walk times exceeded California standards—or whose BMIs were above national guidelines—scored lower on math, reading and language tests than did students with higher fitness levels, even among children whose parents had similar educational backgrounds.

Reading, Writing and Rugby

However strong the correlations between physical fitness and academic performance, they do not necessarily mean that exercising leads to cognitive improvement. They might simply indicate that the parents who encourage their kids to exercise are also the ones who push them academically. Having

FAST FACTS

Academic Athletes

1» **Students who are fit—based on their high aerobic capacity and low body fat—also tend to perform well in school and on standardized tests.**

2» **In addition to regular exercise, brief periods of movement such as jumping or stretching can help improve children's concentration.**

3» **Exercise may turbocharge the brain by raising levels of neuronal growth factors, which foster the formation of new connections between brain cells.**

AGE FOTOSTOCK (*girl stacking blocks*); ATOM A (*soccer ball*) AND OLEG PRIKHODKO (*mortarboard*) *iStockphoto*

Running and other forms of aerobic exercise (*left*) may benefit school performance. Research indicates that some of the biggest effects occur in planning and organizational skills (*below*).

involved parents, rather than being athletic, could explain these children's academic abilities.

To determine whether exercise has a direct effect on reasoning abilities, researchers conduct so-called intervention studies, in which they add athletics to children's daily routines and assess the impact on learning, memory and the ability to concentrate. And many such studies reveal that additional athletic conditioning can boost test scores and school performance. In 2008 kinesiologist Phillip D. Tomporowski of the University of Georgia and his colleagues surveyed results from 12 research teams that had enrolled schoolchildren in exercise regimes lasting between 20 days and six months. Tomporowksi's team concluded that making kids move around more can sharpen intelligence, enhance creativity and planning skills, and improve math and reading performance (based on standard measures of those traits and skills).

In a review of 17 studies (seven of which involved getting kids to exercise more) from 2008, health scientists François Trudeau of the University of Quebec and Roy J. Shephard of the University of Toronto concluded that reserving up to an hour a day for physical activity in school curriculums does not detract from academic achievement. To the contrary, they noted that more exercise often improved school performance, despite the time it took away from reading, writing and arithmetic.

Exercise may benefit academic performance primarily by sharpening a particular set of cognitive functions, some researchers suggest. Many of these fall under the umbrella of executive function, the ability to plan and direct action. In a classroom setting, executive skills help students pay attention, decide when to take notes or ask questions, and organize their homework assignments. Participation in athletics is also thought to expand working memory—the capacity to hold items such as numbers and words in mind just long enough to mentally manipulate them. Exercise has a lesser effect—or in some cases none at all—on perceptual skills such as object recognition, language fluency, and the ability to visualize and mentally manipulate objects or spaces, studies show.

Kids may have to cross a minimum threshold of exertion before they reap cognitive benefits from exercise. In 2007, for example, clinical health psychologist Catherine L. Davis, also at Georgia, along with Tomporowski and their colleagues, randomly assigned 94 overweight children between the ages of seven and 11 to either no exercise time, 20 minutes or 40 minutes of aerobic exercise, such as running and jumping rope, five days a week. Before and after 15 weeks of this program, the children took a standardized test that measured their ability to plan, pay attention and process information. The children in the 40-minute program improved significantly on the planning component, but those assigned to 20 minutes of exercise—as with those required to

(The Author)

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ALISTAIR BERG *Getty Images (children running)*; JIM CUMMINS *Corbis (boy studying)*

Studies suggest that youths must exercise above a minimum amount to reap mental benefits from the exertion. Scientists do not know, however, exactly how much—or what type—of exercise is optimal.

PATRIK GIARDINO *Corbis*

do nothing at all—did not improve on any measure.

Scientists do not yet know exactly how much and what kind of aerobic exercise—team sports, running or biking—most influences intellectual development. The studies differ widely in the kinds of athletics they measure or require, and it may be that any kind of activity that gets the heart pumping qualifies. In certain instances—those in which the exercise involved organized sports—practicing teamwork and game strategies might account for some of the effects of exercise on executive function. In general, kids at the lower end of the performance scale both physically and cognitively have a greater opportunity to benefit from working out than do those who are reasonably competent in the classroom and the gym.

In addition to regular exercise, brief periods of movement can improve kids' concentration. In 2006 education researcher Matthew T. Mahar of East Carolina University and his colleagues reported giving 243 North Carolina third- and fourth-grade students a daily 10- to 20-minute activity break in school. Teachers asked the children to stand up and play energetic games involving clapping, jumping, stomping or other movements. Trained raters observed the children before, during and after four to eight weeks of the drills, measuring their on-task behavior—paying attention to the teacher, participating in class discussions, and so on. The researchers found that by participating in the program, the children stayed on-task during academic instruction an average of 8 percent more than before. The most distractible students improved their attention spans by 20 percent. Thus, not only do lasting changes in fitness improve performance, but simply giving children a chance to move during the school day can enhance their ability to learn.

Brain-Building Workouts

Although scientists still do not know exactly why exercise benefits the brain, animal studies hint that physical activity may spur the growth of neurons in brain regions important to memory and executive function. Studies dating back to the 1970s showed

Physical activity raises the levels of key proteins that help build the **infrastructure for learning**.

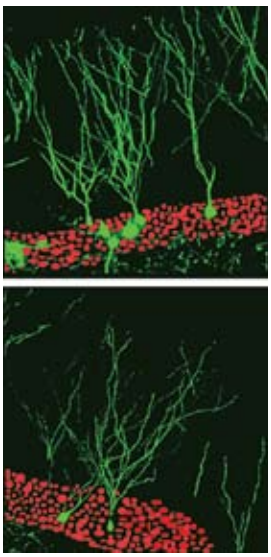
that rats raised in spacious cages furnished with toys, branches to climb, and other objects to stimulate them physically and mentally develop a thicker cerebral cortex, a brain area that handles high-level reasoning and decision making (among many other functions). Rats that showed these brain changes performed better on memory tasks than did animals raised in small, empty cages. The rodents in these studies benefited from both physical exertion and mental stimulation, however, making it unclear which contributed to cognitive changes—or if both factors did.

More recently, scientists have begun to discover specific brain chemicals that might spur the improvements in mental fitness. Neuroscientist Henriette van Praag of the National Institute on Aging in Baltimore and her colleagues, among other research teams, have discovered that exercise increases the amount of key proteins that help to build the brain's infrastructure for learning and memory in mice. These molecules include vascular endothelial growth factor (VEGF), which fuels blood vessel growth, and brain-derived neurotrophic factor (BDNF), which facilitates the development of the long extensions of neurons called axons that link one cell to the next. Such biological carpentry can create or fortify large brain networks that exchange and process information.

Specifically, physical activity may prompt construction in a part of the hippocampus called the dentate gyrus. The hippocampus is often likened to a switchboard in the brain that acts in the service of memory, tying thoughts together so that they stick in the mind [see "Making Connections," by Anthony Greene; Scientific American Mind, July/August 2010]. In a study published in 2008 neurobiologist Shu-jie Lou and his colleagues at Shanghai University trained five-week-old juvenile rats by letting them run on an exercise wheel in their cage. (A healthy rat can easily run several miles a day.) After one week, brain cells in the dentate gyrus of these rats contained higher levels of VEGF, BDNF and other molecules that promote neuron growth than did comparable brain areas in rodents that had not run. Yet excessive running proved counterproductive: after a week of wheel spinning several hours per day, the concentration of neural growth factors in the hippocampus dipped. Thus, extreme forms of exercise might be less intellectually stimulating than more moderate physical activity.

Some evidence suggests that neural growth factors rise after aerobic exercise in humans, too. In 2008 psychiatrist Cindy Law of the University of Hong Kong and her colleagues found that a single 15-minute stepping exercise increased BDNF levels in the blood serum of 16 volunteers. (These levels are typically reduced in psychiatric syndromes such as depression in which neuronal growth and reconstruction are also stunted, suggesting that serum levels correspond with levels in the brain.) And yet, just as in rats, extensive vigorous exercise can have the opposite effect. In another small 2008 study epidemiologist Shuzo Kumagai of Kyushu University in Japan and his colleagues documented diminished BDNF concentrations in 12 men who engaged in activities such as distance running or tennis for more than 16 hours a week over more than three years as compared with 14 sedentary individuals.

Of course, not every kid can be a star athlete, and to succeed in school many children must opt for doing homework instead of running in the yard for hours on end. But parents should encourage their kids to squeeze some exercise into their busy days. And educators should recognize that physical education is about building the brain as well as the body and should put it center stage in the curriculum. If teachers want their students to pay attention, they should consider letting them jump, stomp and bend their bodies regularly during the school day. Most children have a natural inclination to move, so all the adults have to do is get out of their way. M



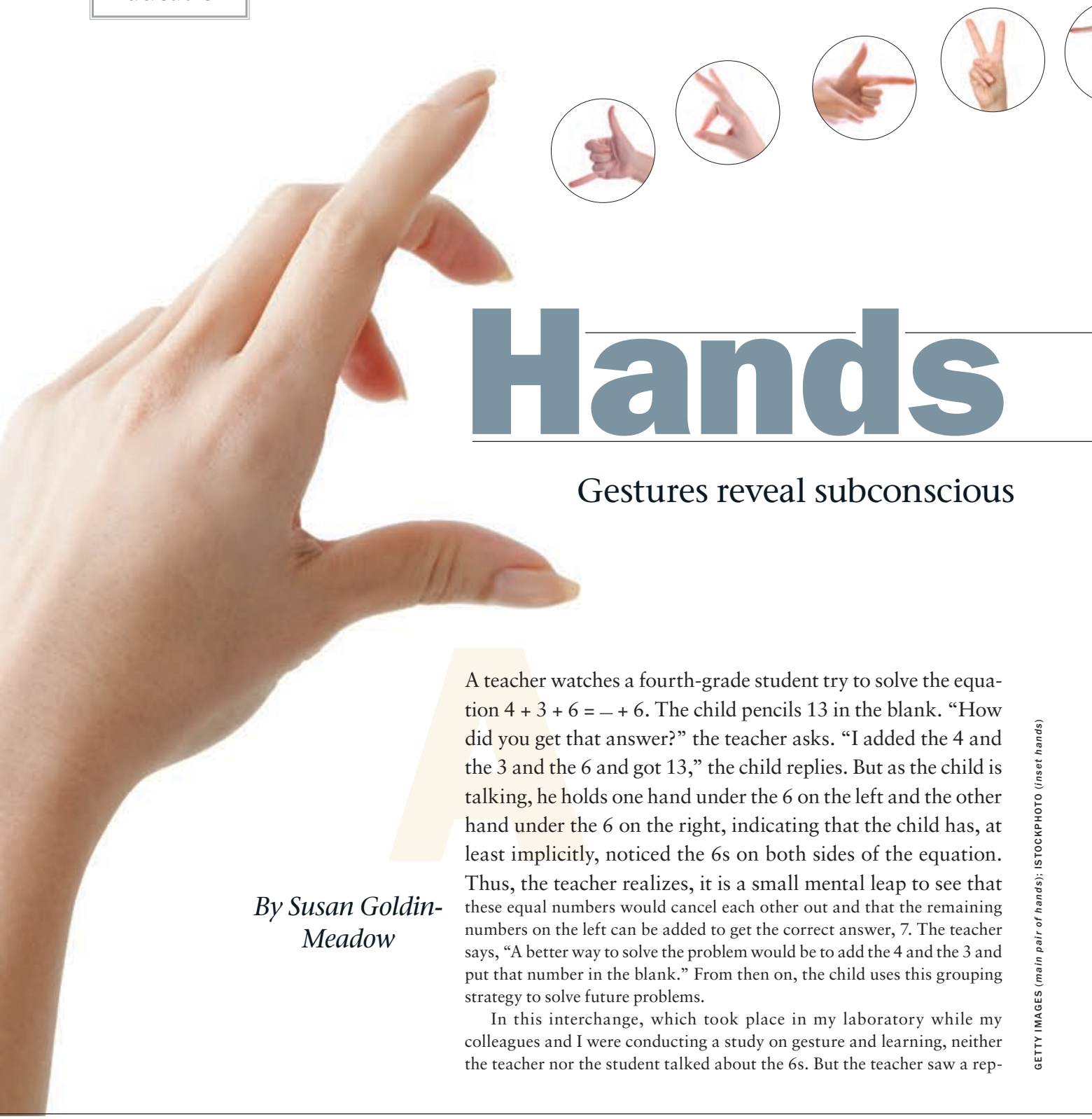
Exercise spurs the growth of cells in the hippocampus, a part of the brain involved in memory. Scientists injected a retrovirus into mice that causes new neurons to produce a green fluorescent protein. Four weeks later they saw more new brain cells in running (*top*) than in sedentary (*bottom*) rodents.

CORBIS (*mouse on exercise wheel*); COURTESY OF HENRIETTE VAN PRAAG *National Institutes of Health* (*micrographs*)

(Further Reading)

- **Exercise and Children's Intelligence, Cognition, and Academic Achievement.** P. D. Tomporowski et al. in *Educational Psychology Review,* Vol. 20, No. 2, pages 111–131; June 2008.
- **Physical Fitness and Academic Achievement in Third- and Fifth-Grade Students.** D. M. Castelli, C. H. Hillman, S. M. Buck and H. E. Erwin in *Journal of Sport and Exercise Psychology,* Vol. 29, pages 239–252; 2007. **http://webs.csu.edu/~sbuck/isat.pdf**
- **Be Smart, Exercise Your Heart: Exercise Effects on Brain and Cognition.** C. H. Hillman, K. I. Erickson and A. F. Kramer in *Nature Reviews Neuroscience,* Vol. 9, No. 1, pages 58–65; January 2008.
- **Physical Education, School Physical Activity, School Sports and Academic Performance.** F. Trudeau and R. J. Shephard in *International Journal of Behavioral Nutrition and Physical Activity,* Vol. 5, No. 10; February 25, 2008. **www.ijbnpa.org/content/pdf/1479-5868-5-10.pdf**
- **Exercise and the Brain: Something to Chew On.** H. van Praag in *Trends in Neuroscience,* Vol. 32, No. 5, pages 283–290; 2009.

SPECIAL REPORT
Physical Education



Hands

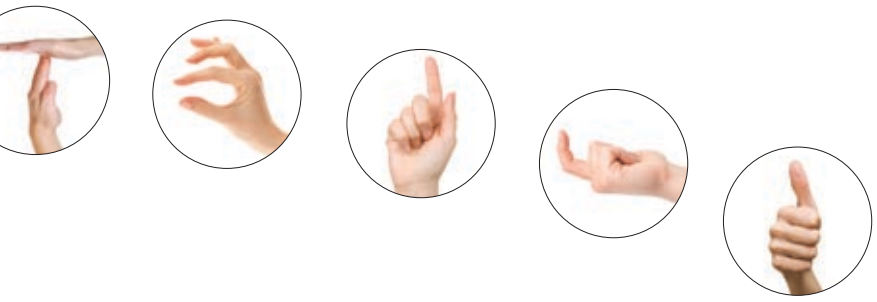
Gestures reveal subconscious

By Susan Goldin-Meadow

A teacher watches a fourth-grade student try to solve the equation 4 + 3 + 6 = _ + 6. The child pencils 13 in the blank. "How did you get that answer?" the teacher asks. "I added the 4 and the 3 and the 6 and got 13," the child replies. But as the child is talking, he holds one hand under the 6 on the left and the other hand under the 6 on the right, indicating that the child has, at least implicitly, noticed the 6s on both sides of the equation. Thus, the teacher realizes, it is a small mental leap to see that these equal numbers would cancel each other out and that the remaining numbers on the left can be added to get the correct answer, 7. The teacher says, "A better way to solve the problem would be to add the 4 and the 3 and put that number in the blank." From then on, the child uses this grouping strategy to solve future problems.

In this interchange, which took place in my laboratory while my colleagues and I were conducting a study on gesture and learning, neither the teacher nor the student talked about the 6s. But the teacher saw a rep-

GETTY IMAGES (*main pair of hands*); ISTOCKPHOTO (*inset hands*)



in the Air

knowledge and cement new ideas

resentation of the two 6s in the student's gestures, prompting the explicit instruction about grouping. If the student had not gestured in this way, the teacher might have suggested a different method of tackling the problem that might not have been so effective.

We often use gestures when explaining a complex topic, but we also move our hands when simply chatting. These spontaneous hand movements are not random; they reflect our thoughts. Children who are on the verge of mastering a task advertise that fact in their gestures. Listeners glean information from these movements, often unconsciously. Good teachers change their instruction in response to a student's gestures, altering their explanations and even their own gestures. Children learn better from this kind of tailor-made instruction.

Children naturally shape their own learning environments just by moving their hands. But encouraging kids to use gestures while they learn can amplify the effect, bringing out their implicit knowledge and thus changing the way they approach problems and tasks. Kids master tasks faster, and they better remember how to do them when they move their hands. In this way, bringing gesture into the classroom can facilitate learning.

Deaf children who are not exposed to conventional sign language, which is depicted here, may invent their own communication systems using only their hands, representing different parts of speech with specific gestures.

SILKE WERNET *laif/Redux Pictures*

Portal to the Mind

Everyone gestures, moving their hands in synchrony with their words. These movements come in several varieties. In addition to pointing, we use our hands to pantomime actions—for example, rotating our fingers as though twisting open a jar—and to capture abstract ideas—say, moving a hand forward when talking about the future.

Gesturing is innate: people who have been blind since birth gesture, even though they have never seen anyone else do it. The fact that congenitally blind speakers move their hands when talking to other blind people suggests that we do not always gesture for our listeners. We also gesture for ourselves.

Gesturing is so natural that people often fail to notice that they are doing it. In some of our experiments, we avoid telling our subjects what we are really studying to avoid provoking self-conscious responses that might compromise the results. When the experiment is over, though, and we explain that we were examining their gestures, participants often apologize profusely for not having gestured—even though they gestured liberally throughout the study. People are often equally unaware of others' gestures, yet they nonetheless absorb the information and seamlessly integrate it into what they gather from the words they hear. Indeed, gesture may gain much of its power to influence how we think and learn from the fact that it remains covert.

I began investigating gesture as a result of my in-

FAST FACTS

Actions Speak Loudly

1» **Congenitally blind people move their hands when talking, implying that we gesture not only for our listeners but for ourselves.**

2» **Common gestures include pointing, pantomiming actions and capturing abstract ideas by, say, moving a hand forward when talking about the future.**

3» **Children who are on the verge of mastering a task advertise this fact in their gestures.**

4» **Encouraging kids to use gestures can bring out their implicit knowledge and thus change the way they think.**

Gesture may gain much of its power over how we think from the fact that **it remains covert.**

terest in the origins of language. Back in the 1970s, I studied deaf children who invented their own communication systems using only their hands, representing nouns, verbs and other parts of speech through specific gestures. To determine how much the deaf children's communication systems differed from the gestures that surrounded them, I needed to know what hearing people do with their hands when they speak. So, in the mid-1980s, I started examining gestures in hearing children as they were thinking and learning.

Gesture and nonverbal communication had long been considered a window onto people's moods and attitudes. By the time I took up the topic, psychologists such as David McNeill of the University of Chicago and Adam Kendon, now at the University of Pennsylvania, were starting to explore what gesture can tell us about how people think, as opposed to how they feel [see "Gestures Offer Insight," by Ipke Wachsmuth; Scientific American Mind, October/November 2006]. My colleagues and I followed this thread connecting gesture to thought. Our studies over the past 25 years link these characteristic hand motions to the emerging study of embodied cognition—the ways that knowledge and awareness are grounded in physical sensations and actions.

Mommy's Hat

In one of my first studies of gesture, in 1986, I watched kids as they tried to explain their answers to a popular conservation-of-matter question. In this problem, a demonstrator pours water from a tall, thin glass into a short, wide glass and asks, "Is the amount of water in the second glass the same as, more than or less than the amount that had been in the first glass?" Of course, the amount has to be the same, but many young children see that the water is at a lower level in the second glass and say that the amount has decreased. As we watched the children answer verbally, my colleagues and I noticed that they often also gestured.

To determine whether we could find meaning in those gestures, we videotaped the children and turned off the sound, separating the gesture from the speech. We also listened to the audio without watching the videotape, to focus on the speech. We found that, at times, the information we gleaned from the children's gestures was not the same as what they said. For example, a child might say that the amount of water had decreased when it was poured into the wider glass because "it's shorter," but his gestures—two hands shaped like C's, mirroring the width of the glass—would show that he knew, at some implicit level, that the width of the glass was also important.

Toddlers may combine gesture and speech to communicate more than they could with words alone. When a young child, say, points to an object such as a carrot but utters a noun such as "Tommy," he may be trying to say "Tommy's carrot."

Similarly, the student attempting to solve 4 + 3 + 6 = __ + 6 uttered the wrong answer, but by placing his hands underneath the two 6s, he indicated an awareness of a strategy that would lead to the right one. Such mismatches between gesture and speech occur in other contexts as well. They often capture a piece of knowledge of which the speaker is not fully aware. For example, toddlers who are just learning to talk may utter "Mommy" but point at a hat. This behavior does not mean that the toddler thinks Mommy is a hat. Instead the toddler is combining gesture and speech as if to say "Mommy's hat." In 2005 we reported that producing such gesture-speech combinations is a sign that the child is on the cusp of uttering his first two-word sentence. After observing children over time, we were able to predict that two or three months after a child produced her first gesture-speech combina-

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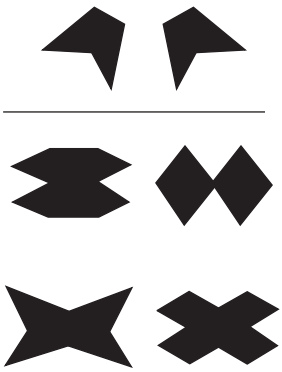
GETTY IMAGES (*hands*); AGE FOTOSTOCK (*boy with carrots*)



In one experiment, preschoolers were asked to mentally combine two shapes (*top*) to match one of four figures (*bottom*). (Correct match appears at the bottom left.) Children's gestures often indicated a better way of solving the problem than their words did.

tion, she would speak her first two-word sentence.

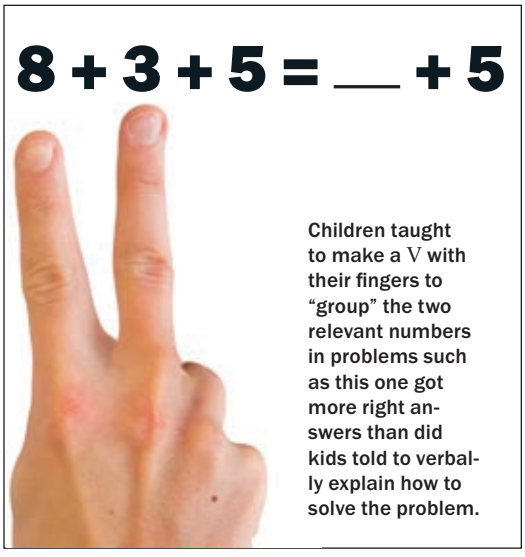
More generally, people whose gestures convey different information from their words are often on the verge of making progress on a task, whether that is an arithmetic problem, a leap in language development or a conceptual insight into the physical world. A person's gestures may represent an alternative way of tackling a problem than the one he or she is expressing in words. In one experiment, we asked preschoolers to mentally combine two pieces of a shape to determine which whole shape they matched. We found that some preschoolers would talk about the number of "points," or corners, the shape had—information that was largely irrelevant to solving the problem—but at the same time would produce a gesture illustrating how the pieces could be moved to fit one of the shape choices [*see illustration above*]. In this case, as in the addition problem described earlier, the gestures reveal a more pertinent strategy than the speech they accompanied.

In such instances, explicit instruction on how to solve a problem often brings rapid results; in fact, teaching tends to benefit students whose gestures differ from their speech more than those whose gestures and speech jibe. When we give instruction in the task to children who cannot solve a math problem or who do not yet understand conservation of matter, the children who produce gesture-speech mismatches of any type when trying to explain the material are the most likely to improve after instruction. The child in our math example was ready to receive advice on how to solve the equation, as were the preschoolers who talked about "points" but gestured about moving the pieces, and their gestures advertised that fact to anyone who was paying attention. In these receptive learners, instruction may serve to move the implicit knowledge conveyed in gesture to the forefront of consciousness, enabling it to trump erroneous or poorly formed ideas. Paying attention to the covert information in gestures can reveal which kids are ready to move on and which are not.

Cementing Memory

The act of gesturing not only reflects what people know but can, if deliberately encouraged, change the way they think—often for the better. Telling kids to gesture while they talk can speed learning. In a study published in 2007 psychologists Sara Broaders of Northwestern University and Susan Wagner Cook, now at the University of Iowa, along with Zachary Mitchell, then my research assistant, asked 70 third and fourth graders to solve a set of mathematical equivalence problems (such as 6 + 4 + 2 = __ + 2) twice. After all the students took a first crack at these problems, we told some of them to move their hands and the others to use just words, while they explained their answers. We then gave all the children a lesson in how to work out the problems and asked them to solve a new set of problems. Students who gestured prior to the lesson answered more problems correctly than did those who kept their hands still. Moving their hands helped the children learn the information presented in the lesson.

When we looked closely, we noticed that the children who gestured suggested new strategies with their hands that they had not previously expressed in words or actions. For example, one child pointed at the 6, the 4 and the 2 on the left and then produced a take-away gesture near the 2 on the right, illustrating an "add up all the numbers on the left and take away the number on the right" strategy. This knowledge remained dormant in the children who were not told to gesture, although we believe they must have had it, because all the children in our study solved and explained the problems in exactly the same way before the lesson. Thus, gesture not only reflects the presence of implicit knowledge but also can help bring it to the forefront of a child's



Children taught to make a V with their fingers to "group" the two relevant numbers in problems such as this one got more right answers than did kids told to verbally explain how to solve the problem.

SOURCE: "EARLY SEX DIFFERENCES IN SPATIAL ABILITY," BY S. C. LEVINE, J. HUTTENLOCHER, A. TAYLOR AND A. LANGROCK, IN *DEVELOPMENTAL PSYCHOLOGY*, VOL. 35; 1999 (*shapes*); ANSSI RUUSKA iStockphoto (*fingers*)

We gesture even when a listener cannot see us. Gesturing helps us think—in part, by bringing implicit or hidden knowledge to the front of our minds.

GETTY IMAGES (*hands*); MOTHER IMAGE/CULTURA/CORBIS (*girl on phone*)

mind, furthering his or her progress as a learner.

In addition to encouraging kids to gesture at will, teachers can also instruct children to produce specific gestures that capture particular concepts. In a study published in 2008, I found that instructing kids to produce particular gestures—as opposed to letting them make whatever gestures they want—helps kids remember what they learn. Before giving 84 third- and fourth-grade children a math lesson, Cook, Mitchell and I taught one group of children to say "I want to make one side equal to the other side" (the equalizer strategy) and to produce hand movements conveying that idea (sweep the left palm under the left side of the equation, then sweep the right palm under the right side of the equation). We told another group to repeat the words only and a third group to simply make the hand movements.

Then Cook taught the children to apply the equalizer strategy—using both gestures and speech—to a set of math problems of the same type. Before and after each problem, the children repeated the words or the gestures, or both. All of them solved the same number of problems correctly after the lesson, but when they were tested a month later using similar problems, only those who had gestured during the initial lesson continued to solve the problems correctly. (The nongesturers reverted to their old ways.) All that mattered was that children gesture: the kids who only gestured remembered as much as those who used both speech and gesture, suggesting that teaching children gestures tailored to a lesson—in this case, pantomiming a correct problem-solving strategy—can make learning last. Using the body to convey an idea appears to cement that idea in the child's repertoire.

Next we wondered whether a teacher could introduce an idea or strategy only by directing a student to produce appropriate hand movements—without any overt verbal instruction. In a study published in 2009 we taught children the equalizer strategy verbally but introduced a different strategy (grouping) only by suggesting certain hand move-

Relevant knowledge remained dormant in the children who were not told to gesture.

Gesturing while talking could lighten the cognitive load of narrating anything complex.

ments. For the equalizer strategy, all the kids were taught to say "I want to make one side equal to the other side" when solving problems such as 8 + 3 + 5 = __ + 5. We told some of them to simply say these words. Others repeated the words and made hand movements that grouped two of the addends: for 8 + 3 + 5 = __ + 5, children made their first and middle fingers into a V and placed it under the 8 and the 3 [*see bottom illustration on page 52*]. Then they pointed at the blank with the same hand. To find out how much of the effect might be the result of just moving the hands, we asked a third group to recite the equalizer speech and use their hands to suggest grouping the wrong two numbers—making a V under the 3 + 5. In all cases, the teacher's verbal instruction referred to the equalizer strategy only.

Even though all the children talked about the equalizer method, the kids who gestured about the correct grouping strategy solved the most problems correctly. Perhaps even more encouraging, the kids who made a V under the wrong two numbers got more correct answers than did those who did not gesture about grouping at all—it seems that they had extracted some aspects of grouping from their partially correct gestures. Moreover, the gesturers who improved after the lesson suddenly began talking about grouping, indicating that the knowledge had become explicit even though the teacher had not talked or gestured about it. Thus, the children's ability to explain grouping after the lesson must have originated in their own gestures; they learned a new technique just by moving their hands in a particular way.

Making the Telling Easier

Gesturing may also aid learning by shouldering some of the cognitive burden. When a problem is hard, hand movements may accomplish some of the necessary "thinking," the way writing a problem down can make it easier to solve. My colleagues and I tested this hypothesis by assessing the effect of gesture on a problem designed to tap the same cognitive resources as memorizing a list of words. If gesture eased the mental effort, or cognitive load, needed to solve the problem, the act of gesturing should improve people's ability to remember the words.

In one of my team's studies, published in 2001, after giving children and adults a list of words to memorize, we told them to solve a math problem and to explain their solutions. For some of the problems (but not for others), participants gestured while they delivered their explanations. When the participants gestured, we found that they recalled more of the words on the list than when they did not—suggesting that gestures reduced the cognitive load of the math problem, leaving more brainpower available for remembering the words.

My colleague psychologist Raedy Ping and I found a similar effect of gesture on cognitive load more recently when we asked five- to seven-year-olds to explain their responses to the conservation-of-matter problem (the experiment mentioned earlier

GETTY IMAGES

Sleight of Hand

Gestures not only transmit accurate information but also can mislead. In a particularly striking example, we once noticed that a teacher's gestures inadvertently led a student to an incorrect strategy for solving a math equivalence problem. While verbally describing the correct strategy, the teacher pointed at all four numbers in the equation, a gesture the child read as an instruction to add up all the numbers in the problem. The child then put that sum in the blank.

Gestures can also bias witnesses. We know that a question such as "What color was the hat the man was wearing?" can sway a witness to state that the man in question was wearing a hat even if he was not. In a recently published study Northwestern University psychologist Sara Broaders and I discovered that child witnesses can also be misled by a more neutral question such as "What else was he wearing?" if, say, the interviewer produces a "hat" gesture (moving the hand as though to tip a hat). In our experiment, we interviewed 39 five- and six-year-olds over a 10- to 12-week period about a live music demonstration we had arranged for their classes. We asked them about events that happened during the demo as well as some that had not occurred, providing details in our interviews in both speech and gesture that might mislead the children. The result? Our suggestive gestures misinformed them just as powerfully as did our slanted verbal queries. —*S.G.-M.*

Students benefit when a teacher conveys different information in her gestures than she does in her speech. This strategy apparently gives kids more information about a topic or the ways to solve a problem.

wherein water is poured from one container to another). Thus, gesture seems to be a way of off-loading information from the mind, improving its ability to focus on other work or on other facets of a difficult problem. Gesturing while talking could, in principle, lighten the load when narrating anything complicated, for example, when telling an intricate story, describing how two people are related or explaining how gravity works. Using your hands can make the telling easier, allowing you to attend to other aspects of the conversation—such as a listener's facial expression or what you will say next.

In the classroom, gesture has additional uses. If teachers pay close attention to children's hand movements, they may be able to see the leading edge of a child's knowledge and thereby determine what the child is ready to learn next. Teachers can also tell what the child's misconceptions are and try to correct them. Teachers should encourage their students to gesture, not only to find out what they know but also to provide an engine for intellectual growth in the children.

In addition, teachers can incorporate gestures into their lessons. Our research reveals that kids especially benefit when a teacher suggests one correct strategy in words and another in gesture, offering a gesture mismatch of their own. For example, on the problem 7 + 2 + 4 = __ + 4, one teacher said, "You can solve this problem by making one side equal to the other side," an equalizer strategy, while at the same time gesturing an add-subtract strategy. That is, the teacher pointed at the 7, 2 and 4 on the left side of the equation in succession and then produced a take-away gesture near the 4 on the right (to suggest adding up the numbers on the left and subtracting the number on the right). Providing two strategies in different modalities seems to give the child more information about how to solve a problem. But teachers need to be careful not to inadvertently misdirect students with their gestures, because hand movements can mislead as well as inform [*see box on opposite page*]. Yet, in general, cultivating gesture in the classroom can smooth the path toward knowledge. M

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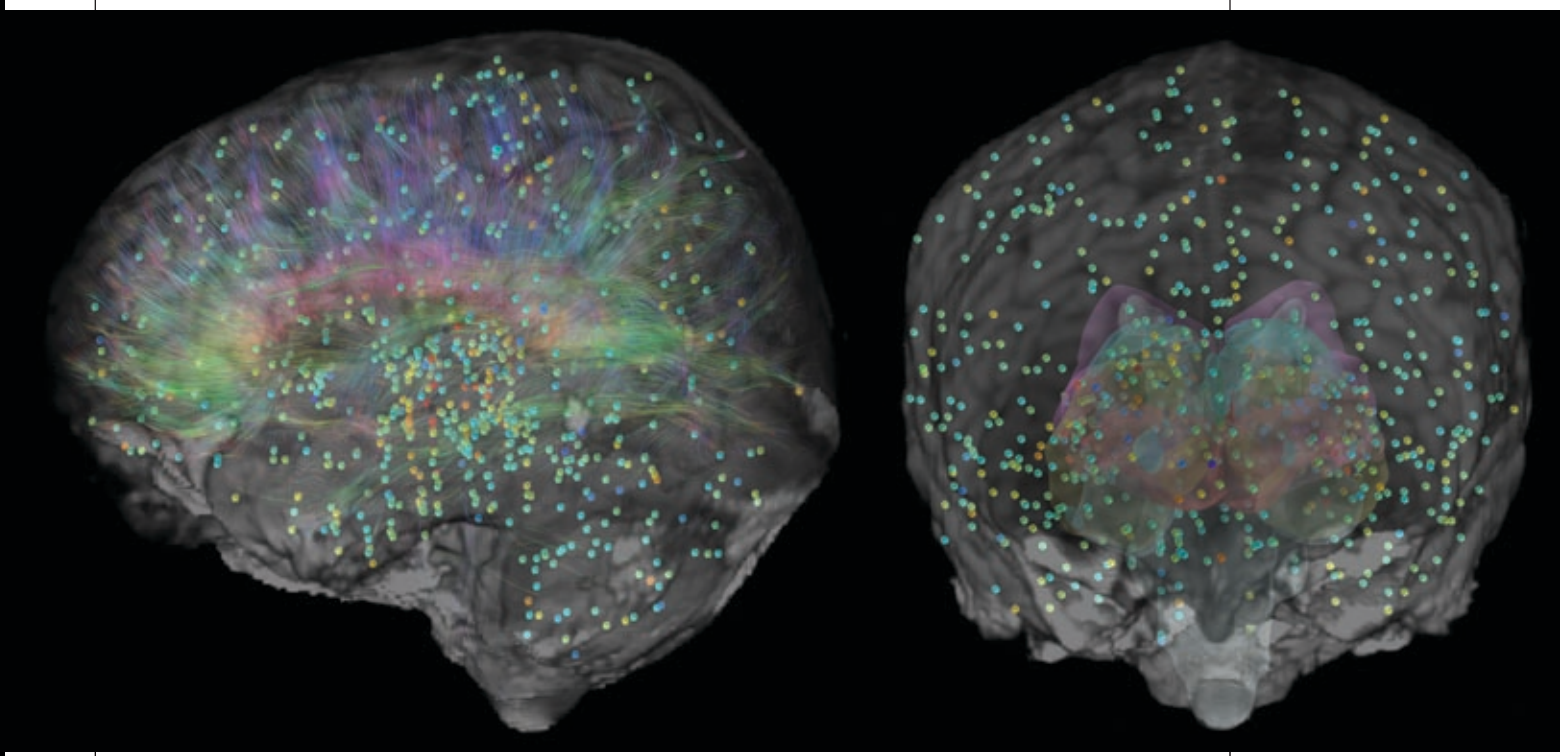
CORBIS

MAPPING THE MIND

A meticulously constructed atlas of the human brain reveals the molecular roots of mental illness—and of everyday behavior

By Allan R. Jones and Caroline C. Overly



COURTESY OF THE ALLEN INSTITUTE FOR BRAIN SCIENCE

Scientists have long sought to understand the biological basis of thought. In the second century A.D., physician and philosopher Claudius Galen held that the brain was a gland that secreted fluids to the body via the nerves—a view that went unchallenged for centuries. In the late 1800s clinical researchers tied specific brain areas to dedicated functions by correlating anatomical abnormalities in the brain after death with behavioral or cognitive impairments. French surgeon Pierre Paul Broca, for example, found that a region on the brain's left side controls speech. In the first half of the 20th century, neurosurgeon Wilder Penfield mapped the brain's functions by electrically stimulating different places in conscious patients during neurosurgery, triggering vivid memories, localized body sensations, or movement of an arm or toe.

In recent years new noninvasive ways of viewing the human brain in action have helped neuroscientists trace the anatomy of thought and behavior. Using functional magnetic resonance imaging, for instance, researchers can see which areas of the brain "light up" when people perform simple movements such as lifting a finger or more complex mental leaps such as recognizing someone or making a moral judgment. These images reveal not only how the brain is divided functionally but also how the different areas work together while people go about their daily activities. Some investigators are using the technology in an attempt to detect lies and even to predict what kinds of items people will buy; others are seeking to understand the brain alterations that occur in disorders such as depression, schizophrenia, autism and dementia.

But such studies reveal only the relative activity

ABOVE: In these 3-D renderings derived from the Allen Human Brain Atlas, the dots mark the locations at which a single gene is turned on—typically serving as a template for a protein molecule. (Hotter colors such as red indicate more gene activity and cooler colors such as blue less.) Thin lines visible in the image on the left are nerve fibers. The outlines of internal brain structures appear in the image on the right. LEFT: In this structural model created from an MRI brain scan, each color represents a subdivision of the cerebral cortex.

Before building their high-tech atlas of the human brain, Allen Institute researchers embarked on a mission to map gene activity in the mouse brain (*below*), which is significantly smaller and much less complex than its human counterpart (*left*).

	Human	Mouse
Weight	Three pounds	0.01 ounce
Volume	1,400 cubic centimeters (small cantaloupe)	1.5 cubic centimeters (jelly bean)
Number of neurons	100 billion	75 million

levels in different regions of the brain and the ways they change under certain circumstances. They do not disclose the biological underpinnings of these alterations in brain activity. To truly understand how autism unfolds, say, or how best to treat depression, scientists want to know what is happening inside the cells that control brain activity.

Genes, of course, provide the instructions for the molecular machinery inside a cell. Thus, biologists have long been engaged in a complementary effort to connect certain genes to defined disorders to get a molecular handle on those diseases. Indeed, researchers have now connected more than 500 genes to Parkinson's disease, more than 600 to multiple sclerosis and more than 900 to schizophrenia. The ever expanding list of gene candidates is both a blessing and a curse. Although somewhere in this genetic stockpile lies the key to understanding these disorders, as the gene lists grow scientists have to laboriously sift through an increasing number of candidates and their interactions.

Now our team at the Allen Institute for Brain Science has developed a high-tech bridge between brain anatomy and genetics: an online interactive atlas of the human brain showing the activity of the more than 20,000 human genes. Preceded by a similar atlas of the mouse brain, the Allen Human Brain Atlas, which will expand in coming years, was launched in May with an initial body of data that already provides the most detailed view of gene activity in the human brain ever created. Now, for example, scientists can quickly determine where in the brain genes that encode specific proteins are active, including proteins that are likely to be affected by a new drug. Such information may help predict a new medication's therapeutic effects, as well as its side effects. With the same ease, a researcher can zoom in on a particular brain structure—say, a region that brain scans have shown to be altered in schizophrenia—and find out which genes are at work there, in an attempt to discover the molecular footprint of the disorder. They also can gain molecular clues to ordinary brain functions such as memory, attention, motor coordination, hunger, and perhaps emotions such as happiness or anxiety.

FAST FACTS

Atlas of Thought

1» **Researchers at the Allen Institute for Brain Science have developed an online interactive atlas of the human brain showing the activity of the more than 20,000 human genes.**

2» **Scientists can now determine where in the brain genes that encode specific proteins are active—including proteins that are affected by medications. Such information may help predict a drug's benefits and side effects.**

3» **Using the atlas, researchers can zoom in on brain structures thought to be altered in mental disorders such as schizophrenia to find the molecular footprint of these diseases.**

4» **The atlas may provide molecular clues to memory, attention, motor coordination, hunger, and perhaps emotions such as happiness or anxiety.**

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It was a big science project, like the Human Genome Project, that went beyond the capabilities of most laboratories.

Great Expectations

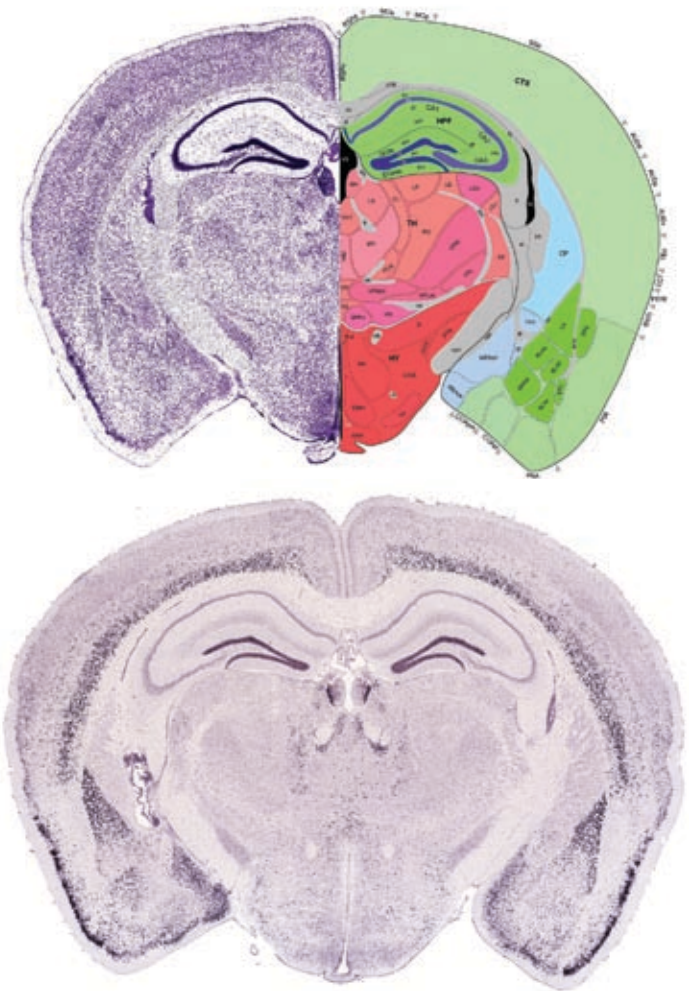
The idea to create a brain atlas grew out of a series of think tank–like meetings convened by philanthropist Paul G. Allen, co-founder of Microsoft, beginning in 2001. Allen, who had been drawn to the mystery of how the brain works, had brought together some of the world's top scientists in biology, genomics and neuroscience to consider the question: What can be done to propel neuroscience to the next level?

During these discussions, one project began to garner the most converts: a three-dimensional map of gene activity throughout the brain for all known genes. Such a map, if publicly accessible online, would enable scientists interested in the role of a particular gene or set of genes in, for example, depression, to bypass the tedious and expensive laboratory work needed to examine possible molecular culprits of the disease one at a time. Instead researchers could search the atlas to see where in the brain the genes are active as well as what other genes, active in the same regions, may be involved. In this way, researchers can identify the best candidate genes quickly and cheaply in silico.

The idea appealed to Allen because it was a big science project, along the lines of the Human Genome Project, that went beyond the capabilities of most labs and could greatly accelerate scientific discovery. So, in 2003, with a generous seed gift of $100 million, he launched the Allen Institute for Brain Science in Seattle.

To lay the groundwork for such an immense project, we first decided to create a map of the mouse brain. The mouse brain is significantly smaller and less complex than the human brain [*see illustration on opposite page*], so it would be a good inaugural project. In addition, such a map would be useful: many researchers test their theories about human behavior and disease in the mouse, because its brain is so similar to ours. The mouse and human brains share, for example, much of the same basic organization and physiology. What is more, 90 percent of the genes in the mouse have a counterpart in our genetic blueprint.

Our first challenge was to figure out how to efficiently map the approximately 20,000 genes in the mouse genome (the mouse has a similar number of genes as a human, suggesting that the complexity of the brain has more to do with its size than its genomic ingredients). At the time, a scientist working in a traditional research laboratory needed about five years to map the activity of just 10 genes throughout the mouse brain. But we saw that the scientific and technological landscape was rapidly changing. First, the results of the human genome effort and the imminent deciphering of the mouse genome would provide us with the molecular codes for the genes we would be mapping. Second, advances in automation had created high-throughput lab machines capable of working around the clock that could complete in hours tasks that would otherwise require weeks of human labor. We believed we could adapt this technology to perform the procedures our project required.



TOP: In this cross-sectional slice from the Allen Mouse Brain Atlas, a purple dye that marks the main bodies of neurons shows their locations in the brain. The right half of the image is a diagrammatic rendering of the stained brain on the left. BOTTOM: In this slice, a dye reveals where one gene is active. Darker staining indicates greater gene activity.

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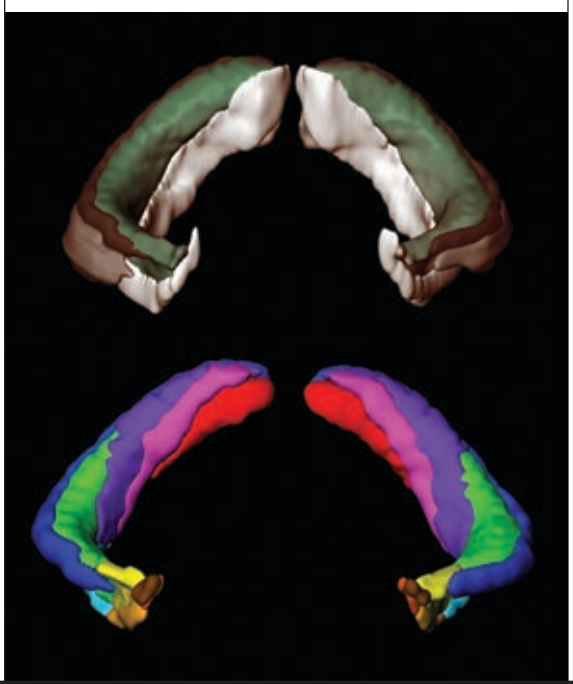
Making Genes Appear

What does it mean to make genes visible in the brain? First, some background: gene activity, also called gene expression, occurs when a gene gets "read"—a complicated process involving, among other actors, a molecular transcript called messenger RNA (mRNA) and ending in the assembly of a protein. Although all of a person's genes are present in every cell, they become active only in certain tissues or at certain times, and it is then that their RNA transcripts and proteins can be "seen." Proteins are critical building blocks and workhorses of every cell in our bodies. In the brain, proteins help with such tasks as building the connections in neural circuits, driving chemical signaling and doing the cellular housekeeping necessary for brain health. Alterations in a gene, known as mutations, create malformed proteins, which in turn can lead to diseases such as Huntington's. Additionally, changes in the regulation of gene expression can lead to too many, too few or misplaced proteins, thereby interfering with normal physiology. Such changes have been implicated in neurodegenerative and neurodevelopmental disorders, for example.

The atlas revealed that at least 80 percent of genes are expressed in the brain, a testament to the organ's complexity.

To see gene expression in the mouse brain, we cut frozen brain tissue into slices thinner than a human hair and bathed each slice in a solution of molecular probes that bind specifically to the mRNA from a single gene. Next, we started a chemical reaction that stained the probes purple, marking their locations within the slice and thus indicating which cells expressed that gene. We then used robotic microscopes to photograph one million of these slices—enough to survey all 20,000 genes, one per slice—and shuttled the resulting image data into a computer database. We transformed that information into a 3-D digital reconstruction of the brain with its gene expression patterns and made it available online. The entire process took just three years.



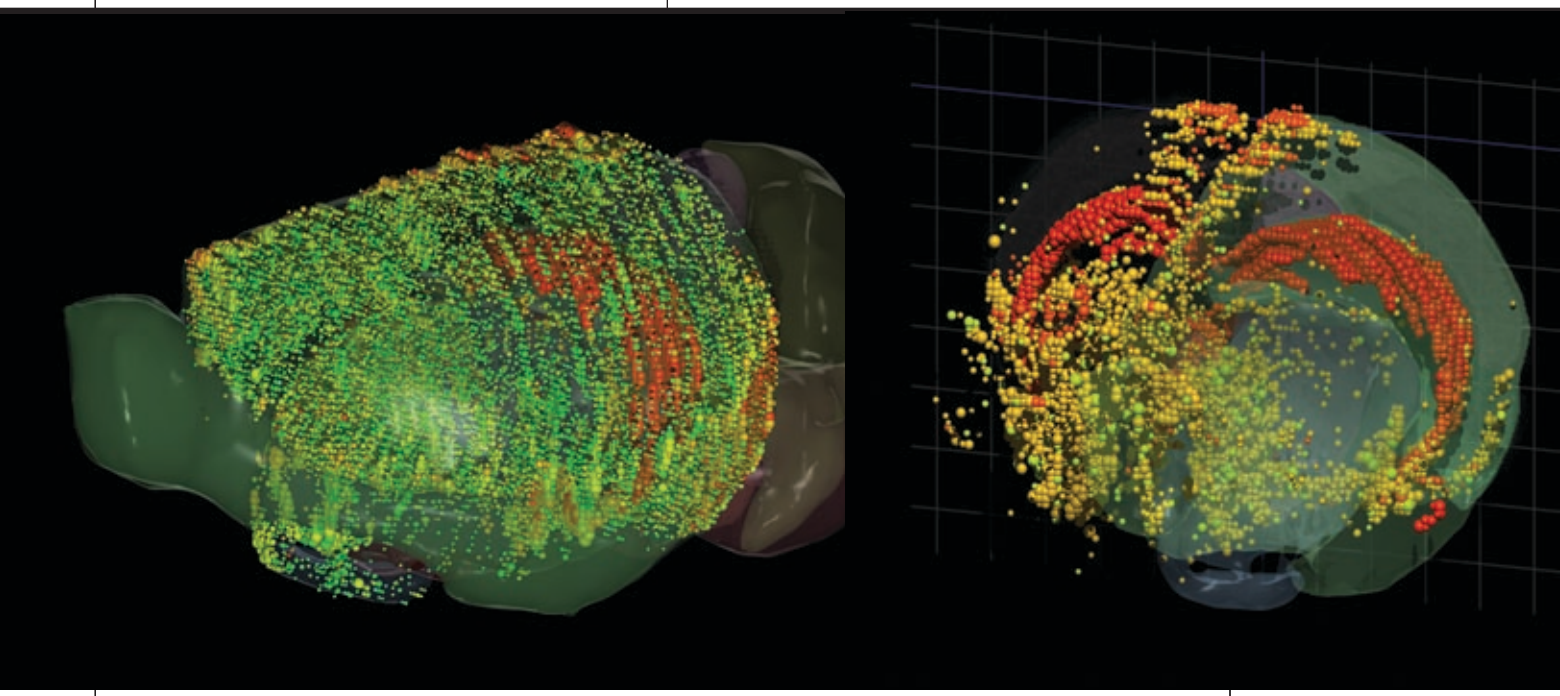
The Allen Mouse Brain Atlas has sharpened our understanding of the structure of the brain. For example, scientists had previously divided the hippocampus, an area involved in memory, into four compartments (*top*), but gene expression data from the atlas reveal that one of these (*green area, top*) is composed of nine distinct sections (*bottom*).

FROM "GENOMIC ANATOMY OF THE HIPPOCAMPUS," BY CAROL L. THOMPSON ET AL., IN *NEURON*, VOL. 60; DECEMBER 26, 2008, REPRINTED WITH PERMISSION OF ELSEVIER

The completed atlas revealed that at least 80 percent of mouse genes are expressed in the animal's brain. That percentage is much higher than previous studies had indicated, perhaps because our method detected mRNA in nooks and crannies that other techniques can miss. That so many genes are active is testament to the brain's complexity. More practically, this finding suggests that many drugs designed to affect proteins in other tissues, such as the liver or kidney, for example, may alter brain function as well.

The vast majority of the genes are expressed in very specific brain regions, representing the specialized function of these areas. These gene expression patterns create identifiable molecular signatures that, for instance, distinguish the cells in the striatum, a deep brain structure involved in basic control of movement, from cells in the cortex, which is involved in higher-level information analysis. Within the cortex, the genes active in the somatosensory area, which processes information about touch, differ from those expressed in the visual cortex.

In general, the structures revealed by the gene expression patterns reflect those that have been worked out by classical neuroanatomists who have been looking at brain sections with their microscopes for more than 100 years. In some cases, however, our technique for visualizing gene expression revealed finer subdivisions within structures than had been seen before. For example, we saw previously undiscovered compartments within the hippocampus, a structure deep inside the brain that plays a key role in memory and learning [*see illustration at left*]. We do not yet know what the cells in these compartments do, but the identification of these new subdivisions may help us better under-



In these 3-D views of the mouse brain, the dots indicate where in the brain a single gene is turned on. The large red arc (*right*) is the memory-making hippocampus, and the red color means that the gene is turned on strongly there, something scientists can now try to explain.

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stand how the hippocampus works and thus, perhaps, identify where and how best to intervene to combat memory impairment in disorders such as Alzheimer's disease.

Working in Concert

One of the most powerful features of the Allen Mouse Brain Atlas, as well as the atlases created later, is the ability to look at the expression patterns of many genes across the brain one at a time, in groups and in different combinations. Previously scientists often could study only one or a few genes at once because of the lab work involved. As a result, many current conceptions of the brain circuits governing complex behaviors may tell just part of the story.

Now, however, scientists have learned that brain wiring and biochemical pathways are sometimes more complex than originally thought. For example, neuroscientists are interested in the circuits that regulate eating and drinking, which hold the key to solving problems such as obesity and anorexia. These circuits, which must integrate internal signals such as hunger and thirst with environmental cues, also provide clues to the function of analogous brain networks.

In the past, scientists explained food and drink consumption by focusing on single gene products, such as the hunger-stimulating hormone ghrelin, or single brain centers implicated in hunger, satiety or thirst. But in a study published in 2008 obesity specialist Pawel K. Olszewski and his colleagues at the University of Minnesota revealed a more complex reality after they used the Allen Mouse Brain Atlas to assess the expression patterns of 42 genes in eight brain structures that had been implicated in the regulation of eating behavior. The researchers found that supposed hunger centers actually contain a mixture of genes, some of which increase appetite and others that diminish it. The results indicate that assigning individual brain regions single functions could be a mistake. They also may help explain the failure of antiobesity drugs that target single proteins, suggesting instead that successful treatments are likely to act on multiple molecules.

The atlas has already yielded insights into the genetic roots of cognitive differences among individuals. In a study published in 2006 neurogenomicist Andreas Papassotiropoulos and human geneticist Dietrich Stephan of the Translational Genomics Research Institute in Phoenix and their colleagues identified a human gene called *KIBRA* with variants that correlate with differences in a person's ability to perform memory tasks, such as trying to remember a list of words after five minutes and then again after 24 hours. The variants were also associated with differences in brain activity in

(The Authors)

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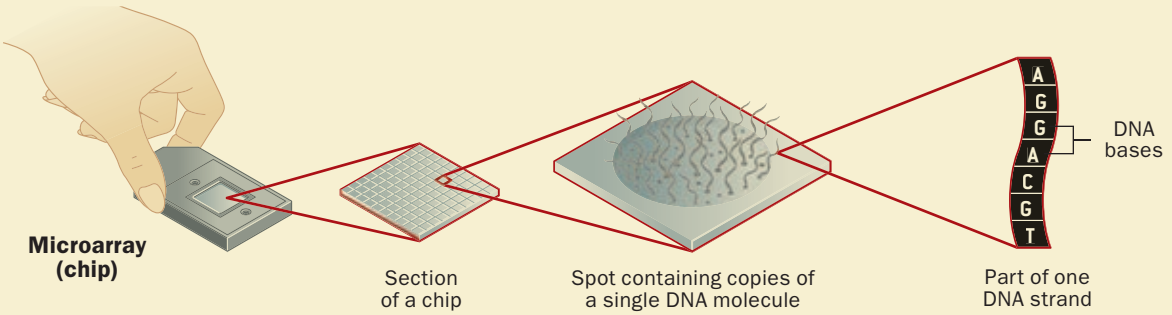
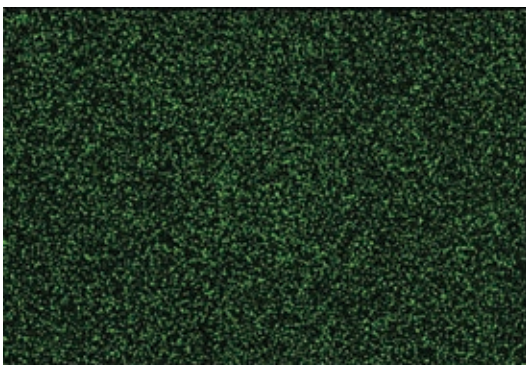
The authors thank Michael McCarthy for his help in the development of this article.

Genes at Work

Researchers used DNA microarrays to construct the Allen Human Brain Atlas. These small chips contain clusters of identical DNA molecules, called probes, within separate small areas. Each probe binds to the RNA transcript of a specific gene—the one that contains a complementary set of chemical units, or bases. In a DNA molecule, the base adenine (A) sticks to thymine (T), and guanine (G) pairs with cytosine (C). The complementary sequence to the strand shown below is (from top to bottom): T, C, C, T, G, C, A. The result of this binding (or lack of it) in each section of a chip is a recording of which genes are active, and to what extent they are active, in a sample of brain tissue.





In this image, a DNA chip that has been exposed to a sample of brain tissue reveals the activity of thousands of genes in one part of the hippocampus. Each spot denotes activity from one gene. The brighter the spot, the more active the gene.

the hippocampus while subjects performed these tasks. By looking up the gene in the mouse brain atlas, the researchers found that the gene is expressed in the hippocampus—sewing up the case that the gene plays a direct role in short-term memory.

From Mouse to Man

Given the stream of findings emerging from the mouse brain map, we hoped that a similar atlas of the human brain would yield even more fruitful insights into diseases and behaviors that may differ between humans and mice. Such discoveries may enable better predictions about, say, which new medicines tested in animals will really work in people. To build this bigger map, however, we needed a different approach. Given the size of the human brain, analyzing gene expression in brain sections one gene at a time would take decades. Our streamlined method involved the use of specialized gene chips, also called DNA microarrays, to measure the activity of all genes simultaneously in each of about 1,000 distinct brain areas. These regions would be represented by tissue samples ranging from the size of a pea (for larger, more uniform brain areas) to that of a pinhead (for smaller, more intricate structures).

Developed in the mid-1990s, a DNA microarray is dotted with numerous microscopic DNA segments, called probes, each of which binds the mRNA for a specifically matched gene and "lights up" to reveal both the presence and level of that gene's expression [*see box above*]. Some gene chips contain tens of thousands of probes, enough to test for the presence of all human genes in a single experiment. Although it cannot provide the same fine, cellular-level detail as the mouse brain atlas, the microarray strategy is fast and yields numerical data—as opposed to images of slices of mouse brain—that are much easier to analyze, enabling scientists to draw correlations between different patterns of gene activity that might elude the human eye.

In March 2009, after nearly two years of planning, we were ready to begin making our human brain map. One hurdle remained: we needed a brain. The brain had to be free of disease or other abnormalities. It had to be whole and fresh and obtained and quickly frozen within 24 hours of death—or the mRNA we were looking for would degrade and we could not detect gene expression. Such brains are rare, and when they are available other organs must be collected first for people in need of an organ transplant. Only if our 24-hour window had not closed by then and surviving family members gave their consent could we have the brain.

Nevertheless, we received the first of several brains needed for the atlas in July 2009, kicking off the 10-month process required to complete data

JARED SCHNEIDMAN DESIGN (*top*); COURTESY OF THE ALLEN INSTITUTE FOR BRAIN SCIENCE (*bottom*)

generation for one brain. We scanned the brain using MRI, creating a three-dimensional digital image onto which we mapped all the microarray data, along with that from tissue sections stained to reveal the brain's cellular architecture. This spring's debut of the atlas contained an almost complete data set for that first brain, including nearly 50 million gene expression measurements.

Looking Ahead

Neuroscientists hope that the Allen Human Brain Atlas can help them explain, on a deeper level, some of the more tantalizing results from human brain-imaging experiments. For example, fMRI results suggest that the fusiform face area of the brain's temporal lobe, which is involved in the recognition of faces, tends to be underactive in children with autism. Other research suggests that, in people with certain genes, areas of the brain affected by Alzheimer's are hyperactive when they perform memory tasks, a finding that may help predict their risk of acquiring the disease. And individuals with schizophrenia exhibit hyperactivity in the hippocampus and dorsal lateral prefrontal cortex, which may reflect a loss of inhibitory neuron function that contributes to their symptoms.

Deciphering the biology underlying these changes is essential to understanding these disorders. What changes in the brain cells of the autistic child cause these facial perception areas to be hypoactive? How do the genes that confer an increased risk of Alzheimer's affect the function of the memory centers of the brain? What is going on—on the molecular level—within the neurons of the hippocampus and prefrontal cortex of an individual with schizophrenia? Now scientists working on these and other topics can begin to match the brain areas they are identifying with gene expression data in the atlas. From these data, biologists can start to construct the molecular processes underlying the activity revealed by fMRI and other imaging techniques.

In the coming years the atlas will be expanded and enhanced. More data will be generated from additional brains, enabling analyses across individuals that may reveal which features of brain anatomy and chemistry are shared and where individual variation may occur. In addition, we will incorporate more sophisticated data-search and visualization tools to help investigators more rapidly sift through the immense store of information and home in on those findings that are most relevant to their research programs.

In addition, future upgrades for the atlas will include more gene expression data for key brain structures, such as the hippocampus and hypothalamus, providing the degree of cellular detail available in our original mouse brain atlas and thus further insight into the cellular underpinnings of brain function. The entire atlas is scheduled to be completed by 2013.

Adding to this genetic treasure trove are several other Allen Institute resources. For example, the Allen Developing Mouse Brain Atlas maps changes in gene activity throughout the rodent brain as it grows from an embryo into an adult. It reveals clues to how brain structures form and forge ties during development and how those processes might go awry in developmental disorders such as autism, dyslexia and schizophrenia. The Allen Institute is also spawning smaller-scale maps, including an analysis of the genes involved in human glioblastoma, a devastating form of brain cancer [see "New Hope for Battling Brain Cancer," by Gregory Foltz; Scientific American Mind, March/April 2010]. More than 20,000 visitors explore the atlases and other data every month.

With such resources, along with a growing number of gene databases being compiled by others around the world, we may soon be able to answer some very basic questions about human brain function in health and disease. Perhaps someday these tools may give us a handle on more fundamental and long-standing curiosities such as: How do we think and feel? What is consciousness? And what makes us human? M

➥ For a slide show on the making of the Allen Human Brain Atlas, visit **www.ScientificAmerican.com/Mind/BrainAtlas**

What happens in the brain cells of the autistic child to cause brain regions involved in face perception to be underactive?

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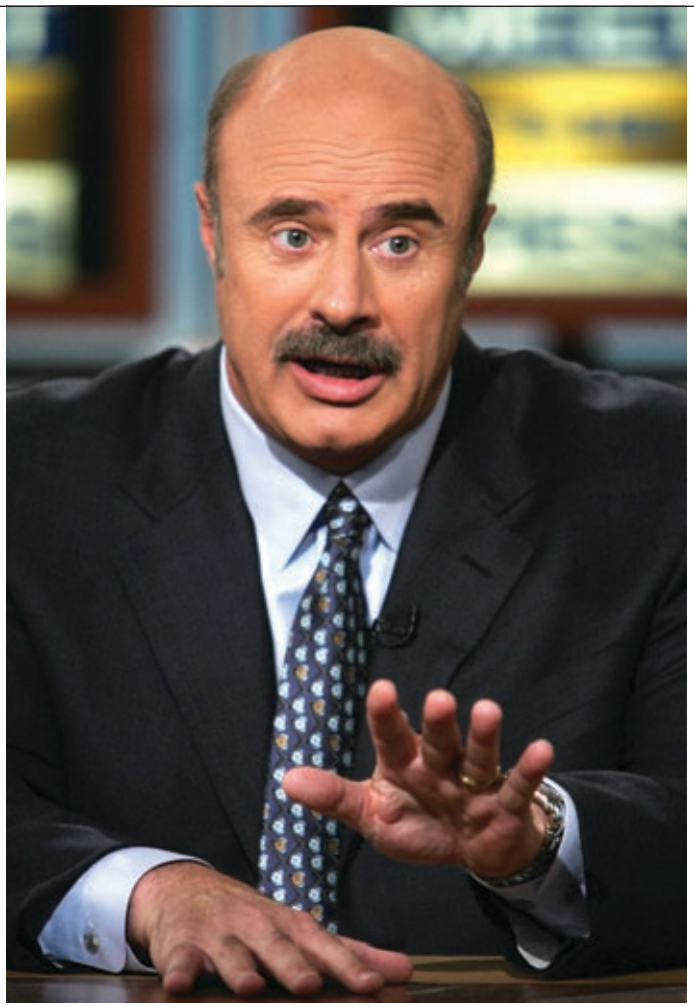
The "Just Do It!" Trap

Why Dr. Phil and Dr. Laura won't solve your problems

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

A WOMAN WHO HAD been married for 14 years called into Dr. Laura's radio show. The woman says she recently realized that she has never loved her husband, and she informs Dr. Laura that she has told her husband that. The couple has received marriage counseling, but Dr. Laura tells the caller that counseling is useless because of her attitude, according to a YouTube recording of the episode. The conversation continues:

Dr. Laura: "What is your question for me?"
Caller: "What type of advice can you give me to try to…?"
Dr. Laura (interrupting): "Too late, too late, you were cruel."
Guest: "At the time …"
Dr. Laura (interrupting again): "Try to make it up to him by just being nice every day. Maybe you're just broken in the I-can-feel-compassion-for-someone department."



Phillip McGraw, known on TV as "Dr. Phil," often dispenses advice in a direct, authoritative way, drawing quick conclusions from scant information.

In an episode of Dr. Phil's television show that first aired on April 1, 2009, Dr. Phil spoke to a guest who was seeking help because she gets very angry at her children and sometimes hits them. His advice: "You can stop. You can stop because you do stop for other people … It's not that you won't, it's just that you don't…."

Participants in the Dr. Laura (Schlessinger) and the Dr. Phil (McGraw) shows seek help for a variety of personal problems, and the advice the hosts provide reaches a lot of people. Earlier this year Dr. Laura's call-in show drew more than nine million listeners per week. At about the same time, Dr. Phil attracted roughly four million viewers per program. Yet neither host claims to practice psychotherapy. What is more, both Schlessinger's and McGraw's typical takes on people's troubles are at odds with much of the psychological literature, which suggests that their recommendations are unlikely to work most of the time and might even do damage.

Although Schlessinger holds a California license in marriage, child and family counseling, her Ph.D. is in physiology, not psychology, making the use of "Dr." as a qualification for giving personal advice misleading. McGraw has a psychology Ph.D. and was licensed as a psychologist in Texas until 2006, when he let his license expire.

Blaming the Victim

McGraw and Schlessinger are right to emphasize personal responsibility and discourage blaming others for problems. Yet they often take individual accountability to an extreme, implying that people are to blame for all their difficulties when, in fact, factors such as an individual's genetic makeup, personal history and current circumstances may contribute significantly to psychological problems. Emphasizing personal control above all else can discourage people from identifying the external issues or situations that might be contributing to their problems and that might need to be addressed.

Another drawback of the Schlessinger and McGraw styles is their lack of empathy—a willingness to understand another person's thoughts, feelings and struggles from that person's perspective. Schlessinger typically spends only a few

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); ALEX WONG *Getty Images* (*Dr. Phil*)

Dr. Phil told a man wanting to marry a woman after a very short courtship, **"You absolutely, unequivocally should not do this!"**

minutes with callers, frequently interrupting them and sometimes referring to their behaviors with derogatory terms, such as "stupid." Her strongly worded advice is usually based on her socially conservative and religious views and often neglects many of the specific problems that the caller is facing. McGraw typically spends somewhat more time listening, but he comes to relatively quick conclusions about the causes of and solutions for his guests' problems, again reflecting little appreciation for the complexities of people's lives.

Studies show that empathy, which helps to create a trusting give-and-take, is a key ingredient in successful psychotherapy.

Recent research suggests that a lack of empathy is a handicap when trying to help people with psychological or social problems. In a 2002 quantitative review of numerous studies psychologist Arthur Bohart, then at California State University, Dominguez Hills, and his colleagues found a correlation between high levels of empathy in therapists and successful outcomes in their patients. In a 1992 study psychiatrist David Burns, then at the University of Pennsylvania School of Medicine, and his colleagues used advanced statistical techniques for distinguishing cause and effect and found that a therapist's ability to empathize not only is correlated with a patient's progress but also contributes to it. Empathy is the cornerstone of psychotherapy, both because therapists need it to provide useful and relevant guidance and because patients benefit from feeling truly understood.

Breeding Resistance

Instead of trying to understand their guests, Schlessinger and McGraw are often confrontational and directive, authoritatively telling people what to do or not to do with relatively little input from the recipients of their instructions. For example, Dr. Phil told a 19-year-old man who was considering marrying a 30-year-old woman with two children after a very short courtship: "You absolutely, unequivocally should not do this!"

However much the viewer might agree, numerous studies reveal that a directive therapist style leads many people to dig in their heels and may even worsen a situation or psychological problem. In 1985 psychologists Gerald Patterson and Marion Forgatch of the Oregon Social Learning Center concluded that directives from therapists who were coaching mothers to deal with difficult children triggered more resistant responses from the mothers than did a supportive approach involving gentle encouragement and belief in a child's ability to change. In a 1993 study psychologist William R. Miller of the University of New Mexico and his colleagues found that therapists who used more directive and confrontational statements elicited more opposition from patients who were problem drinkers. In addition, the more directive the therapists were, the more the clients drank a year after the therapy.

Most psychotherapists know that merely telling people to stop their problem behaviors is rarely helpful, and indeed no data exist to show that anyone has benefited from Schlessinger's or McGraw's advice. After a thorough search of the research literature and the Internet, we could not find a single follow-up study of the participants, formal or informal.

Because Schlessinger's and McGraw's practices are unsubstantiated, we believe that these well-known hosts need to demonstrate that they are not causing harm. Calling what they do "entertainment" or "education" does not exclude them from this requirement. Both shows inaccurately portray how mental health professionals understand and help people. Most psychological problems do not simply reflect a lack of self-control and cannot be changed by simple directives. Believing that they can could lead millions of people to ignore important biological or social causes of their troubles and fail to seek effective treatments for themselves or others. 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)

- **Empathy.** Arthur C. Bohart, Robert Elliott, Leslie S. Greenberg and Jeanne C. Watson in *Psychotherapy Relationships That Work.* Edited by John C. Norcross. Oxford University Press, 2002.
- **SHAM: How the Self-Help Movement Made America Helpless.** Steve Salerno. Crown, 2005.

CORBIS

Faking It

Why wearing designer knockoffs may lead to lying, cheating and cynicism

BY WRAY HERBERT

WITHIN JUST A FEW BLOCKS from my office, street vendors will sell me a Versace T-shirt or a silk tie from Prada, cheap. Or I could get a deal on a Rolex watch or a chic pair of Ray-Ban shades. These are not authentic brand-name products, of course. They are inexpensive replicas. But they make me look and feel good, and I doubt any of my friends can tell the difference.

That's why we buy knockoffs, isn't it? To polish our self-image and broadcast that polished version of our personality to the world—at a fraction of the price. But does it work? After all, we first have to convince ourselves of our idealized image if we are going to sway anyone else. Can we really become Ray-Ban-wearing, Versace-bedecked sophisticates in our own mind, just by dressing up?

New research suggests that knockoffs may not work as magically as we would like. Indeed, they may backfire. Three scientists—Francesca Gino of the University of North Carolina at Chapel Hill, Michael I. Norton of Harvard Business School and Dan Ariely of Duke University—have been exploring in the laboratory the power and pitfalls of fake adornment. They want to find out if counterfeit labels might have hidden psychological costs, warping people's actions and attitudes.

In one study, the scientists recruited a large sample of young women and had them wear pricey Chloé sunglasses. The glasses were the real thing, but half the women thought they were wearing knockoffs. The researchers wanted to see if wearing counterfeit shades—a form of dishonesty—might make the women act dishonestly in other ways.

They asked the women to perform a couple of tasks that presented opportunities for lying and cheating. In one, the women worked on a complicated set of mathematical puzzles—a task they could not possibly complete in the time allowed. When their allotted time was up, the women were told to score themselves on the honor system—and to take money for each correct score. Unbeknownst to them, the scientists were monitoring both their work and their scoring.

And guess what? The women who thought they were wearing the fake Chloé

(Women who thought they were wearing phony Chloé sunglasses **pocketed the petty cash**.)

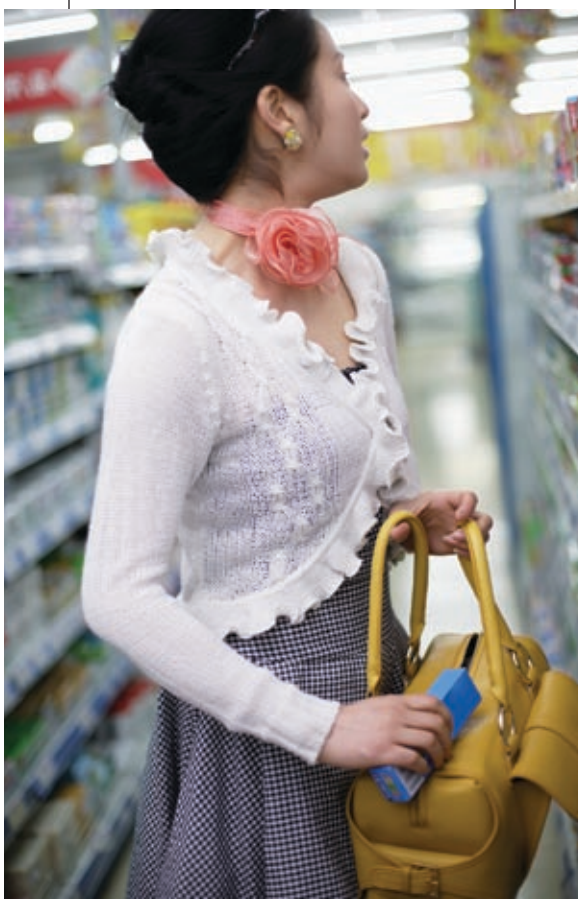
MATT MENDELSON (*Herbert*); JUPITERIMAGES (*woman in sunglasses*)

If wearing counterfeit stuff makes **people feel inauthentic**, might they see others as phony and unethical, too?

shades cheated more—considerably more. Fully 70 percent inflated their performance when they thought nobody was checking on them—and, in effect, stole cash from the coffer. By comparison, "only" 30 percent of the group who knew they wore authentic Chloés cheated.

The Price of Being Phony

To double-check this distressing result, the scientists put the women through a different drill, asking them to indicate whether there were more dots on the right or left side of their screen. Choosing "left" earned them half a cent, and choosing "right" earned them five cents, regardless of whether the answer was correct. In other words, the task forced a choice between a correct answer and the more profitable answer. And again the women wearing what they believed to be knockoffs pocketed the petty cash much more often than did their peers who knew they wore the authentic shades.



When people sport inexpensive replicas of designer duds, they may become more likely to cheat and steal.

SIMON MARCUS *Corbis*

Notably, the women wearing supposedly counterfeit goods cheated even though the "fake" sunglasses were randomly handed out, suggesting that it was not something about their self-image going into the study that led them to cheat. To the contrary, it was the very act of wearing the so-called knockoffs that was triggering the dishonesty.

This is bizarre and disturbing, but it gets worse. The psychologists wondered whether illusory image making might not only corrupt personal ethics but also lead to a cynical attitude toward other people. In other words, if wearing counterfeit stuff makes people feel inauthentic and behave unethically, might they see others as phony and unethical, too? To test this, the scientists again handed out genuine and supposedly counterfeit Chloé shades, but this time they had the volunteers complete a survey about "people they knew." Would these people use an express line with too many groceries? Pad an expense report? Take home office supplies? There were also more elaborate scenarios involving business ethics and a series of statements ("my GPA is 4.0") that the volunteers had to rate as likely to be true or more likely to be a lie. The idea was that all the answers taken together would characterize each volunteer as having a generally positive view of others—or a cynical one.

The result? Cynical, without question. Compared with volunteers who were wearing authentic Chloé glasses, those who had been told that they were wearing knockoffs saw other people as more dishonest, less truthful and more likely to act unethically in business dealings.

So what's going on here? Ironically, as the scientists reported in the May issue of *Psychological Science*, wearing counterfeit glasses not only fails to bolster our ego and self-image the way we hope, it actually undermines our internal sense of authenticity. "Faking it" makes us feel like phonies and cheaters on the inside, and this alienated, counterfeit "self" leads to cheating and cynicism in the real world.

Counterfeiting is a serious economic and social problem, epidemic in scale. Most people buy these fake brand-name items because they are a lot cheaper than the real deal, but this research suggests that a hidden moral cost has yet to be tallied. M

For more insights into the quirks of human nature, visit the "We're Only Human. . ." blog and podcasts at http://onlyhumanaps.blogspot.com

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

(Further Reading)

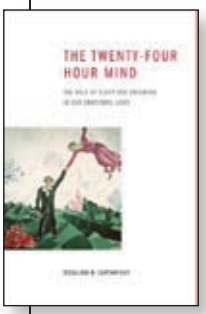
- **The Counterfeit Self: The Deceptive Costs of Faking It.** Francesca Gino, Michael I. Norton and Dan Ariely in *Psychological Science,* Vol. 21, No. 5, pages 712–720; May 2010.
- This article was originally published April 7 on HuffingtonPost.com: **www.huffingtonpost.com/wray-herbert/the-psychology-of-knock-o_b_523218.html**

books

NIGHTTIME PROCESSING

The Twenty-Four Hour Mind: The Role of Sleep and Dreaming in Our Emotional Lives

by Rosalind Cartwright. Oxford University Press, 2010 ($27.95)



Less than six hours of nightly sleep can lead to obesity and even death, but sleep plays an equally important role in regulating our emotions. In *The Twenty-Four Hour Mind* psychologist Rosalind Cartwright gives an engaging account of the history of sleep research. She skillfully weaves in her 50 years' worth of work in the field, delving into her own theories about the purpose of dreams and highlighting the importance of sleep to maintain our physical and mental well-being.

Cartwright proposes that dreams diffuse the impact of otherwise disturbing emotions by matching them with similar experiences already stored in our long-term memory. Her own studies have shown that even when people go to bed angry or sad, their dreams can turn progressively more positive as the night wears on, allowing the person to wake up in a better mood. She has also built her theory on studies in which volunteers played virtual games and later associated the emotional situations in the games to experiences in their own lives. While they slept, volunteers reported pairing the virtual images with memories of similar emotional experiences. Cartwright concluded that this emotional matching process mitigates some of the negative feelings associated with the events.

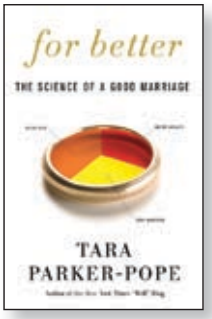
Cartwright describes why comparing these emotional experiences gives us some strange nightly adventures. For instance, you may be dreaming about your boyfriend, and he suddenly morphs into your uncle who recently left his wife. According to several studies, each consecutive 90- to 110-minute sleep cycle integrates more and more associations from your memory, stretching the story line "into increasingly illogical and bizarre connections." By the time you wake up, your dream has turned into complete nonsense. Cartwright's hypothesis, though compelling, is just one theory—sleep researchers are far from agreeing on the origin and purpose of dreams.

Sleep disorders can disrupt a person's emotional maintenance system, a predicament that Cartwright demonstrates vividly through detailed accounts of sleepwalking violence cases. Studies are also now beginning to show that continuous loss of sleep could be an underlying cause of depression, "affecting how we think, feel, define ourselves and relate to others," Cartwright says. *The Twenty-Four Hour Mind* brings home the importance of the brain's "essential night-shift." —*Nicole Branan*

WEDDED BLISS

For Better: The Science of a Good Marriage

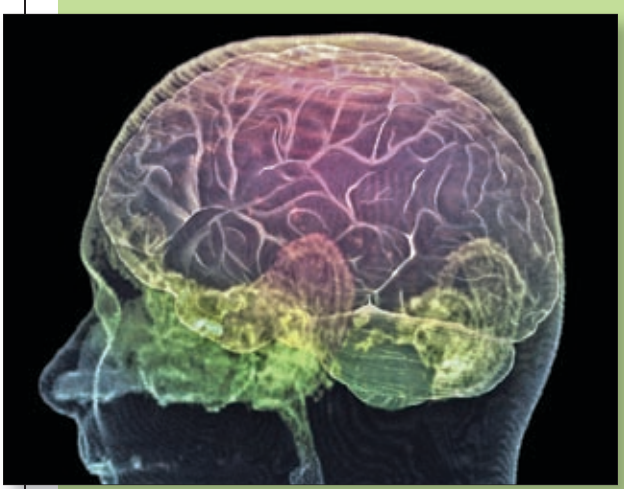
by Tara Parker-Pope. Penguin Group, 2010 ($25.95)



After her own 17-year marriage went bust, *New York Times* health blogger Tara Parker-Pope embarked on a new quest: to see what scientific research has to say about making marriage work. In her new book, she takes us on a journey through more than 100 scientific studies that tell us something about couples who have successful marriages: happy couples use humor to good effect, for example, and set limits on the way they argue. Unfortunately, we do not necessarily learn how the rest of us can have happy marriages, too.

The problem is that the book is based almost entirely on correlational studies—you know, the kinds that do not reveal anything about what is causing what. For example, based on a 1998 study by psychologist John Gottman, then at the University of Washington, and his colleagues showing that people in happy relationships tend to have five times more positive interactions than negative ones, Parker-Pope recom-

>> Philosophy Meets Neuroscience



Do we have free will? Is there meaning to life? A slew of new books provide some insights into how scientists are supplementing Plato with PET scans, hoping to answer these questions.

In ***My Brain Made Me Do It: The Rise of Neuroscience and the Threat to Moral Responsibility*** (Prometheus Books, 2010), Eliezer J. Sternberg examines studies that pinpoint areas of the brain associated with exercising free will and suggests that our ability to decide makes us largely responsible for our actions.

Although we can easily spot and describe the features that make someone wise, defining wisdom is more elusive. In the new book ***Wisdom: From Philosophy to Neuroscience*** (Knopf, 2010), journalist Stephen S. Hall discusses studies that show brain activity corresponding to wise traits, such as moral judgment.

In ***The Brain and the Meaning of Life*** (Princeton University Press, 2010), philosopher and psychologist Paul Thagard discusses the reason we are wired to form social bonds: loving relationships can give a sense of purpose to our lives.

—*Compiled by Valerie Ross and Victoria Stern*

SOVEREIGN, ISM/SPL/PHOTO RESEARCHERS, INC.

mends that when you let someone down, you need to do at least five nice things to make up for it. But in successful relationships, people have far more positive interactions than negative ones; that is where the correlation comes from. Parker-Pope presents no evidence that deliberately moving in the direction of the five-to-one ratio will actually improve a relationship that is failing. My own 30 years of experience as a psychologist suggests that such formulas often fail. When a couple that is struggling leaves a counselor's office equipped with simplistic advice, efforts to behave more positively often seem fake or forced, and an unhappy partner might even find more to complain about, hoping to push his or her partner into buying more gifts or paying more compliments. A system of this kind can unravel in days or even hours.

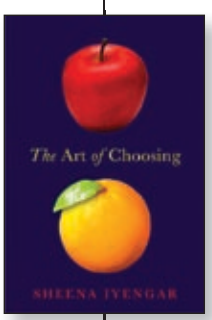
In spite of the upbeat title, the book is also filled with bad news: about the pressures of parenting, recent statistics on cheating (especially by young couples), the weight-gain problem, the toll that snoring takes on marriage (causing one third of couples to sleep in separate beds), and the problem that sexless couples have in rekindling the spark. On the bright side, *For Better* reminds us that many couples do achieve harmony. Being with the right person from the outset undoubtedly helps—an issue not explored in the book—and so does strong mutual commitment to withstand the challenges that every marriage inevitably faces.

—Robert Epstein

BETTER DECISIONS

The Art of Choosing

by Sheena Iyengar. Hachette Book Group, 2010 ($25.99)



In *The Art of Choosing*, Sheena Iyengar, a business professor at Columbia University and a leading expert on decision making, tells us that making sound choices is even more difficult than we think. To learn how to make better decisions, we first need to become aware of the pitfalls we typically encounter.

Iyengar reveals, for example, that having many options to choose from does not lead to better outcomes, despite popular assumptions to the contrary. For instance, she found that consumers were far more likely to buy jam when given fewer flavor choices, not more. "We frequently pay a mental and emotional tax for freedom of choice," she writes. To become better choosers, Iyengar proposes that when confronted with an abundance of options, people should focus first on the easiest elements of the decision and work up to the more complex parts.

She illustrates this point using one study in which Audi buyers had to choose among 144 total car features. One group started with the features that required fewer options, such as whether they wanted leather or upholstered interiors, and worked up to features with many options, such as choosing among 56 colors for the car's interior and exterior. The other group started with the hardest choices and moved toward the easier ones. In the end, those in the group that went from hardest to easiest spent an average of 1,500 euros more on their cars than the other group and reported they were less happy with their decisions.

Iyengar also explains that we often make decisions not based on our tastes but on how we think our decisions will be perceived. In 2000 a team of psychologists at the Massachusetts Institute of Technology and Columbia University showed that people receiving a free sample of beer chose against their tastes to avoid looking like copycats to their peers. Individuals who picked their beers in private, however, chose what they enjoyed and said they were happy with their decision. Iyengar points out that the people who chose against their tastes were often unconscious of what motivated their decision. Thus, she proposes that one way to avoid strong and sometimes silent influences is to try to become more aware of them in the first place.

Ultimately, Iyengar wants us to recognize that our decisions—both the mundane and momentous—are influenced by many factors and that the more we recognize those factors, the more satisfied we will be.

—David DiSalvo

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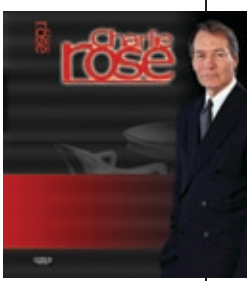


Wouldn't it be great if you could eavesdrop on conversations between some of the greatest brain scientists in the world? Now you can, thanks to veteran television journalist Charlie Rose. In his 13-part series on the brain, which premiered in October 2009 and continues through November 2010, Rose and his co-host, Nobel laureate Eric R. Kandel, along with esteemed neuroscientists, explore a different aspect of the brain in each episode. Recent forays have been into mental illness, anxiety and aging; upcoming topics include decision making and the artistic brain.

Although Rose comes to the table with questions and discussion topics, he is not afraid to let the conversations go in unexpected directions and to touch on contentious topics. In a recent episode, University of Cambridge neuroscientist Daniel Wolpert, a self-described "movement chauvinist," asserted that "we have a brain for one reason and one reason only, and that is to produce adaptable and complex movement." Wolpert went on to explain the controversial idea that movement mediates everything important that we do, including all communication. And in an episode dedicated to the emotional brain, Rose diverted a discussion on drug addiction to talk about the burgeoning fields of sex and risk addiction.

The program feels much more like a conversation between enthusiastic intellectuals than a talk show. After watching Rose's episode on the social brain, we understand why the show's intimate format feels so rewarding, too. "Our brains are not calculators, where you punch in a bunch of numbers and you get a number out at the end," Rockefeller University neurobiologist Cornelia Bargmann explained. "One of the most important things for us is each other."

—Melinda Wenner Moyer

askthe**Brains**

Is altruism a genetic trait?

—Daniel Hall, Oceanside, Calif.

***Nicholas R. Eaton**, a doctoral student in psychology at Washington University in St. Louis, responds, writing in collaboration with professor of clinical psychology **Robert F. Krueger** and doctoral students **Jaime Derringer** and **Abigail Powers**:*

PEOPLE OFTEN GO OUT OF THEIR WAY TO HELP perfect strangers for no apparent personal gain. Many of us assume that altruism is something that parents teach—be nice, don't talk with your mouth full, do unto others.... But science says that altruistic impulses are largely instinctive.

Compelling evidence that altruism is a genetic trait comes from studying our close relative, the chimpanzee. Chimps don't teach their young to be nice the way humans do, but in 2007 scientists at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, found that chimps do behave selflessly, helping their human caretakers reach a stick or unfamiliar chimps open a cage full of food, without expecting a reward.

Soon after, another team from the same Max Planck Institute found evidence that altruistic behavior is innate in humans as well. In 2009 the researchers reported that infants younger than 18 months engaged in altruistic acts, such as helping adults reach objects or open cabinet doors. The infants' attention to the needs of others most likely preceded their full understanding of the social pressures associated with being selfless.

Genes, however, do not tell the full story of what prompts people to be generous. By examining altruism in identical twins, who share nearly 100 percent of their genes, and fraternal twins, who share 50 percent of their genes, researchers can estimate the extent to which genes and the environment contribute to selfless inclinations and behaviors. Overall, these twin studies suggest that genes explain between 30 and 60 percent of altruistic tendencies, with the remaining variation coming from cultural or social effects.

Interestingly, some studies indicate that the influence of genes may vary over time. For example, scientists in the U.K. showed that altruistic behaviors in younger children arose mostly from their environment, such as the family's belief system. In the teenage years, however, when youths typically become more independent, genes have a much stronger influence on altruism.

What is going on in the brain when we experience déjà vu?

—Jennifer Cashen, Carrboro, N.C.

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

ALTHOUGH SCIENTISTS HAVE not pinpointed exactly what goes on in the brain when a person experiences déjà vu, they can make good guesses based on models of memory. All theories of memory acknowledge that remembering requires two cooperating processes: familiarity and recollection. Familiarity occurs quickly, before the brain can recall the source of the feeling. Conscious recollection depends on the hippocampus and prefrontal cortex, whereas familiarity depends on regions of the medial temporal cortex.

When these cooperating processes get out of sync, we can experience déjà vu, the intense and often disconcerting feeling that a situation is familiar even though it has never happened before. This feeling can occur when a brand-new situation is very similar to other events stored in our memory. For example, a Texas airport may seem vaguely familiar to you even though you have never been to Texas. It is possible the airport is strikingly similar to a single event stored in memory—perhaps you recently saw the airport in a movie or magazine. It is also possible that many memories of visiting similar airports create the sensation that you have been to this one. Déjà vu is a stronger version of this kind of memory error.

Patients with damage to their brain's frontal and temporal regions experienced chronic déjà vu. They refused to watch television because they felt they had seen it all before.

The best evidence for a neural mechanism for déjà vu, which around 60 percent of people experience at least once, comes from studies of patients who experience it chronically. In 2005 cognitive neuropsychologists at the University of Leeds in England described two patients with recurring and persistent feelings of déjà vu. The patients refused to read a newspaper or watch television because they felt as if they had already seen it all before. They found it difficult to shop for groceries because they thought they had just purchased those items. The researchers discovered that these patients had damage to their frontal and temporal regions. Harm to these areas likely caused the patients' familiarity circuitry to fire frequently, even when they were in a novel situation. In undamaged brains, déjà vu likely occurs because of processing errors in these same regions. **M**

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

NICHOLAS R. EATON (*left*); PAUL REBER (*right*)

Head Games

Match wits with the Mensa puzzlers

1 COIN COLLECTING

You've got a pocket full of change. You have the same number of nickels, dimes, quarters and half-dollars, and you have a total of $9.90. How many of each coin do you have?

2 LONE SUM

In the box below, each letter has been assigned a value, and the values on each line have been added (across, down and in one diagonal), except one. What is the value of the missing sum?

M	A	T	H	34
H	T	A	M	34
M	M	M	A	38
A	T	T	H	31
37	32	?	36	36

3 WORD MORPH

Transform WARM into HEAT in eight steps, by changing one letter at a time, making a real English word in every step. (Several solutions may be possible.)

WARM

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

HEAT

4 MINGLING

The following two lines each consist of three words that have had their letters interspersed. All the letters are in the right order, and all the words concern the same subject matter. Find the six words.

E G D R A U S W Y È M R I E S S

A C M C E H R E I A D C M D A A R N E M B E R T

5 MIRROR, MIRROR

On each line are two definitions with a space between them. Fill this space with a word that can be read either forward or backward, matching the definition to the left or right.

Example: Cooking utensils POTS Cease

A person who sketches _____ A prize earned, a bonus

Someone who keeps an entrance _____ An identifying label

A four-legged animal ____ A type of grass or a part of a musical instrument

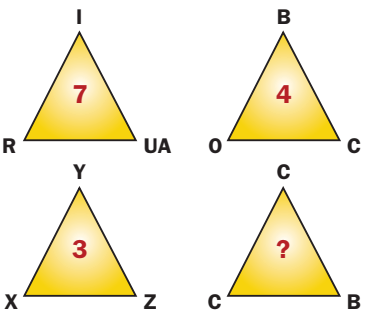
6 MISQUOTED

The following is a common quotation with all the vowels and punctuation removed, and the remaining letters are broken up into randomly sized groups. What is the original quotation?

WHTS NN MRSB YNY THRN MWL DS MLL SSWT.

7 HIDDEN PATTERN

The number in the center of each triangle is related to the letters at its vertices according to a rule. What number belongs in the last triangle?



8 A TEST OF EFFICIENCY

Take the number of "seas" and multiply by the number of "winds." Divide by a baker's dozen plus one, then multiply by the freezing point on a Celsius thermometer. What is your answer?

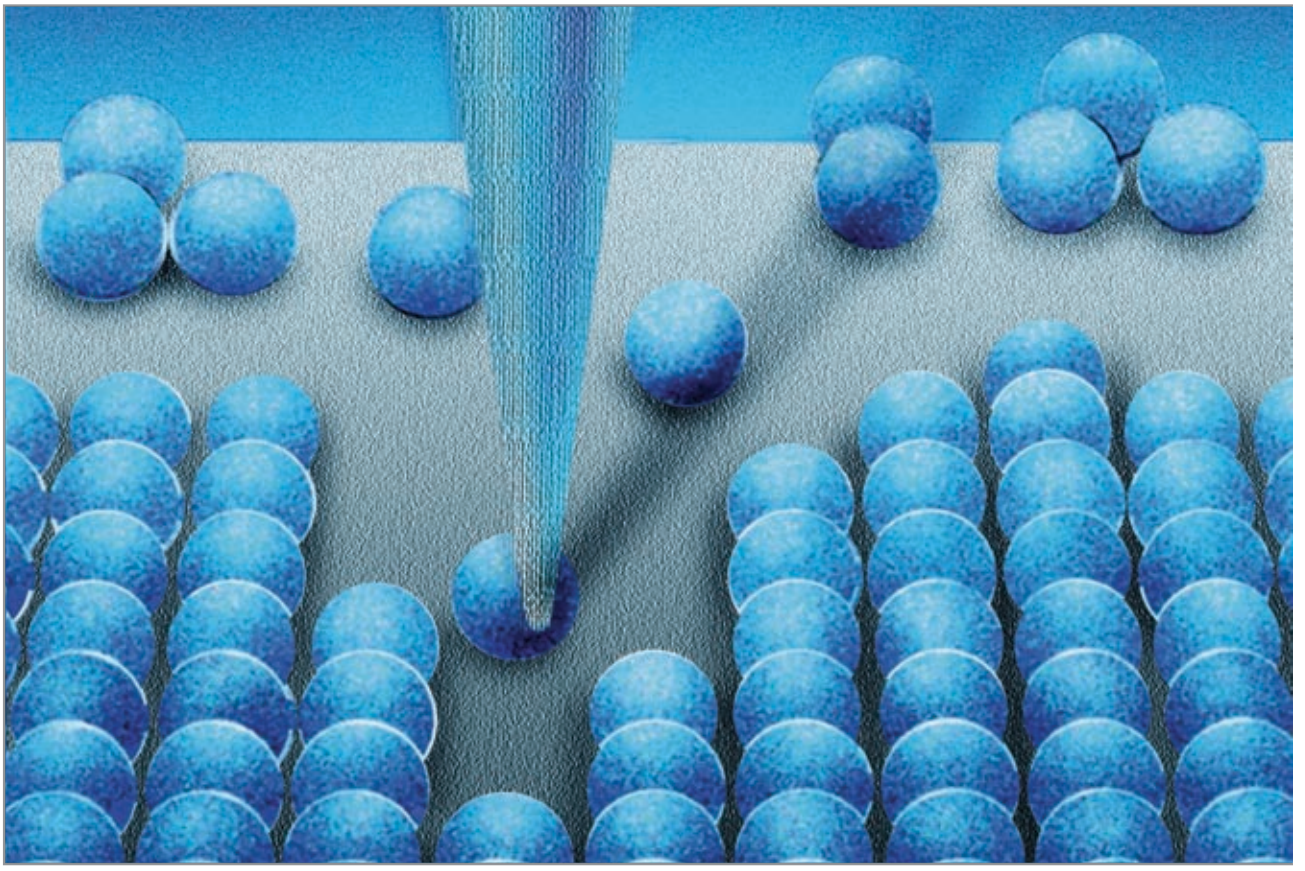
9 DEDUCTION

There is a four-digit number in which the first number is three times the last number and twice the third number, the second number is three times the third number, and the last number is one less than the third number. What is the number?

Answers

1. 11.
2. 32. (M = 10, A = 8, T = 7 and H = 9.)
3. One way to solve it is: Warm, Harm, Hart, Hare, Here, Herd, Heed, Head, Heat.
4. Edam, Gruyère, Swiss; American, Cheddar, Camembert.
5. Drawer, Reward; Gateman, Nametag; Deer, Reed.
6. What's in a name? A rose by any other name would smell as sweet.
7. 3. (Consonants are worth 1, and vowels are worth 2. The number in the middle is the sum of the letters on the points.)
8. 0.
9. 6932.

Dwayne Godwin is a neuroscientist at the Wake Forest University School of Medicine. Jorge Cham draws the comic strip Piled Higher and Deeper *at www.phdcomics.com.*



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