ADHD DRUGS: ARE THERE HIDDEN RISKS? *page 38*

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Pump Your Brain

Cognitive-enhancement drugs have been in the headlines a great deal lately—they stoke your gray matter, enabling greater focus and attention for longer periods of time, users say. But their long-term effects are uncertain and unknown, on both brain and body. In the meantime, there's something you can do that helps both areas but that doesn't have any known mental health risks. As study after study has shown, simple physical activity not only builds your physique and cardiovascular health: it also helps to sharpen the wetware in your skull and thwarts mental decline as you advance in years. Turn to page 24 for our cover story, "Fit Body, Fit Mind?" by psychologist Christopher Hertzog and his colleagues. You'll be glad you did.

For another, unique view on the connection between body and brain, flip to the back page of this issue for a delightful new offering we have for readers: Mind in Pictures. Neuroscientist Dwayne Godwin and illustrator Jorge Cham will explore brain science in playful—and insightful—cartoons in this new editorial department. First up is "Your Aging Brain," which reflects on the topics that are addressed in the cover story.

A different kind of brain performance question is explored in "Do ADHD Drugs Take a Toll on the Brain?" Of course, drugs that treat attention-deficit hyperactivity disorder have provided enormous benefits for many thousands of patients, and nobody should make any decisions about their suitability without consulting a professional. But the article, by Edmund S. Higgins, which starts on page 38, discusses evidence that raises concerns about the long-term consequences of such medications. Understanding about the related brain mechanisms will grow with further research, and we expect that such medicines ultimately could be improved in the future. Naturally, *Scientific American Mind* applauds all such efforts to provide better mental health for everyone.

Mariette DiChristina
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COVER IMAGE BY AARON GOODMAN; HAIR AND MAKEUP BY ELIZABETH YOON; COSMETICS BY M.A.C.

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FEATURES

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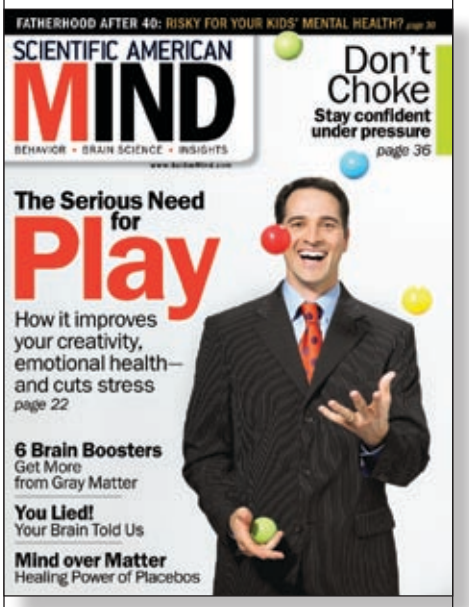

PLAYTIME FOR EVERYONE

Yesterday while going through our mail, *Scientific American Mind*'s cover line jumped out at me: "The Serious Need for Play. How it improves your creativity, emotional health—and cuts stress" [article by Melinda Wenner]. I was thrilled to see "play" on the cover.

Psychiatrist Stuart Brown is a role model for all of us who strongly believe in play. Readers might like to check out the National Institute for Play Web site, www.nifplay.org.

Pat Rumbaugh
Takoma Park, Md.

As a public school teacher of 18 years, I have been dismayed by the reduction of recess time and by the pushing down of inappropriate curriculum into kindergarten and first grade. In a six-hour kindergarten day, kids get a total of 40 minutes of unstructured play. Gone are most of the "house" corners where kids pretended. You won't find a blocks corner either. I believe strongly in public education, but I couldn't bear to put my daughter in that setting. She is now in a Waldorf school, where play is nurtured and childhood is protected.

"farmergirl"
adapted from a comment at
www.ScientificAmerican.com/
Mind-and-Brain

My delight at seeing a grown-up juggling on the February/March cover quickly damped down on reading the article. Silly me—hoping adult creativity, emotional health and stress reduction would be featured as indicated. By the second paragraph, I was reading about the importance of play for kids.

I concur, but that's not what I wanted to see. As a professional learning and performance program designer and consultant for business and government, I know the value of play to promote interest, involvement and improvement. Play looks different for adults, but discovery, fun problem solving, creative daydreaming, a little competition and many other techniques produce stunning results.

In my long experience, playfulness and periods of free thought and action produce a sense of satisfaction and mastery for people—in the workplace.

Judith Blair
Boulder, Colo.

PRIMER FOR PERFORMANCE

It is interesting that the title of Elizabeth Svoboda's article, "Avoiding the Big Choke," focuses on the negative rather than the positive. It could have been, for instance, "Perform under Pressure." As a mental skills consultant for athletes, musicians and other performers, I would recommend starting from a more positive perspective.

Overall, the article was interesting, but I think the part discouraging people from "taking their time" was a little dodgy. In my experience, taking time can often be helpful, as a deep breath can allow the mind and especially the body to relax. The important difference here, which I think the article does not take into account, is that such time can be used proactively to focus on key words such as "smooth" or "powerful," which you mention as a useful technique. Using these phrases with a relaxed body is likely to be more successful than using them with an overhyped one.

Mason Astley
adapted from a comment at
www.ScientificAmerican.com/
Mind-and-Brain

MOVE TO THE MUSIC

As a physician with an antiaging practice, I can strongly support the value of exercise in combating disease states, including the aging process, as Emily Anthes wrote in "Six Ways to Boost Brainpower." And what could be better for your health and longevity than the combination of music, socialization and exercise: dance!

"jlewismd"
adapted from a comment at
www.ScientificAmerican.com/
Mind-and-Brain

FATHERLY CONCERN

"The Father Factor," by Paul Raeburn, is an excellent article. I had the pleasure of being introduced to Vanderbilt University psychiatrist Howard Meltzer, whom you quote in the article, and I share his concern about the lack of knowledge—on the part of both the lay public and medical professionals—about this cause of one third or more of noninherited cases of schizophrenia and autism. I recommend for further reading an article by Columbia University urologist Harry Fisch, entitled "Older Men Are Having Children, but the Reality of a Male Biological Clock Makes This Trend Worrisome," in the January issue of the journal *Geriatrics*. Couples are waiting longer to start a family, and advances in reproductive technology are allowing older men and women to consider having children. I am concerned about these trends.

"anniepema"
adapted from a comment at
www.ScientificAmerican.com/
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I am 51 years old and have a child with autism. If I had known that my advanced age increased the risk that I would have an autistic son, would I have done anything differently? Would I have taken the risk of never knowing this boy, my son? I don't think so. I hope not.

"parvasedapta"
adapted from a comment at
www.ScientificAmerican.com/
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NEUROPOETRY

As a long-time subscriber, student of the sciences and budding neuroscience researcher, I greatly appreciate your magazine. I wrote this "neuropoem" and thought you'd enjoy it. It is based loosely on Victorian verse, weaving timeless infatuation with modern neuroscience terminology using classic landscape imagery.

I Love Your Mind

How I'd love to go walking
Through the orchard of your mind
Fertile neurons branching
Intricately evermore
Arboretum lushly laden with
sweet serotonin

My fingers itch to dig up your
deep-rooted dopamine
My taste buds drown themselves
in craving
Your savory acetylcholine
I long to climb up your axon
And shake ripe neurotransmitters
From the delicate tips of your
dendritic branches

I ache to see your action potential
in action
To be blinded by the searing speed
of your electric signal
As it sparks from node to node
To behold the violent beauty of
vesicles fusing with your pre-
synaptic membrane—
Pouring their contents into your
synaptic cleft
How I wish to be your postsynaptic
cell
So that I may be flooded by your
molecules

Inhibitory, excitatory—it thrills
me to my core
I hyperpolarize every time you're
near me
Gripped by glycine
Transfixed, mesmerized
Living to be behind your eyes
Depolarize me anytime

Emily Brown
Berkeley, Calif.

ERRATA "Building around the Mind," by Emily Anthes [April/May/June 2009], misspelled the name of Columbia University's John Zeisel in his second mention.

"Learning by Surprise," by Daniela Fenker and Hartmut Schütze [December 2008/January 2009], incorrectly stated that dopamine is the messenger sent from the hippocampus in response to stimuli. The messenger is glutamate. Glutamate indirectly activates the substantia nigra and ventral tegmental area, which contain cells whose axons release dopamine in the hippocampus.

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GETTY IMAGES (*slot machine*); ISTOCKPHOTO (*cherries*)

>> ADDICTION

Close Calls Count

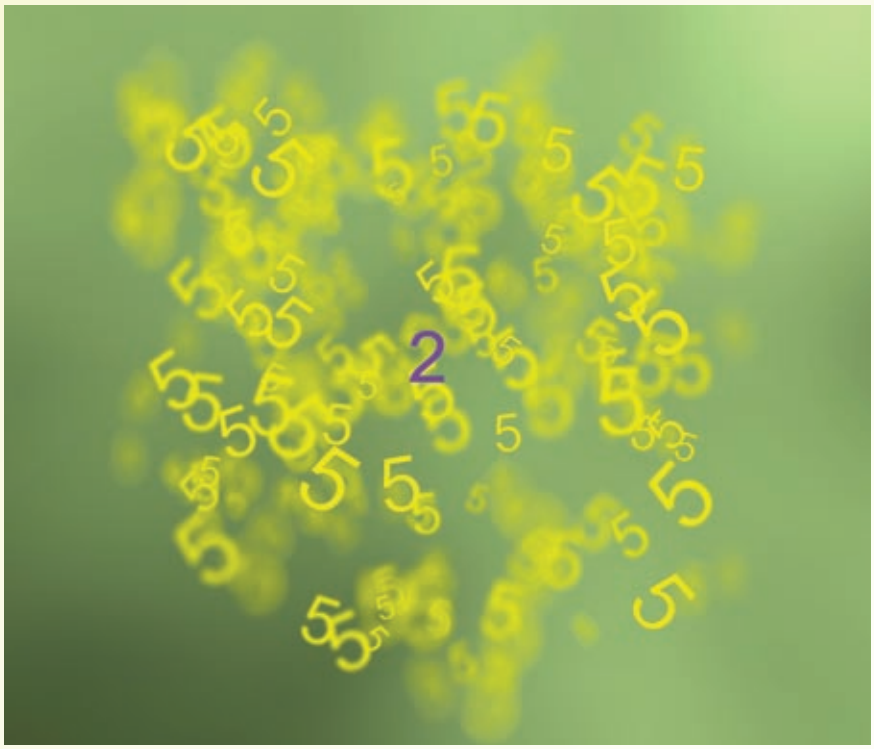
To our brain, a near miss is as good as a win

Close but no cigar, the saying goes. But new research shows that when it comes to gambling, the human brain seems to take a very different approach. In our head, near misses, such as a lottery ticket just one number away from the jackpot, are interpreted as wins.

Using functional MRI, Luke Clark of the University of Cambridge and his colleagues looked at the brains of 15 volunteers who were playing a computerized slot machine. Unsurprisingly, wins activated the players' reward system, whereas complete misses did not. When the wheel stopped just one position from the pay line, however, the reward system of volunteers' brains got excited the same way it did after a win—there was much activity in the striatum and the insula, areas involved in reinforcing behavior with positive feedback.

This type of reinforcement makes sense in behaviors that involve actual skill, such as target shooting, because a sense of reward provides encouragement to keep practicing, Clark says. "A near miss in a game of chance doesn't mean that you are getting better," he notes, yet it seems that the brain mistakenly activates the same type of reinforcement learning system in these situations.

The findings expose the underpinnings of gambling addiction, according to Clark. Even though all volunteers were nongamblers, those whose brain showed a greater response in the scanner also reported feeling more desire to continue trying after near misses. Excessive recruitment of these reward areas, therefore, may be a risk factor for compulsive gambling, Clark says. —*Nicole Branan*



EQUINOX GRAPHICS/SPL/PHOTO RESEARCHERS, INC. (*numbers*); CYRIL RUOSO *Biosphoto/Peter Arnold, Inc.* (*macaques*); JUPITERIMAGES (*schoolgirls*)

>> SENSES

Genetic Overlap

Sensory quirks share gene regions linked to autism

Synesthesia is not caused by one gene, as long believed, but by many, according to a recent *American Journal of Human Genetics* study. Researchers linked the neurological condition—characterized by unusual sensory experiences such as seeing colors when hearing sounds [see "Hearing Colors, Tasting Shapes," by Vilayanur S. Ramachandran and Edward M. Hubbard; SCIENTIFIC AMERICAN MIND, Vol. 16, No. 3; 2005]—to regions on four chromosomes. Included in these areas: genes previously implicated in autism, another condition involving excess connections in the brain. That doesn't mean synesthetes are autistic (or vice versa). But it may explain synesthesialike symptoms reported in some forms of autism. Follow-up studies are under way to see if synesthesia is more common in those with autism and to explore other genetic coincidences, including possible connections among synesthesia, dyslexia and perfect recall (extraordinary memory ability). *—Andrea Anderson*

>> PRIMATES

Monkey Education

Macaque mothers demonstrate tool use to their young

How do baby monkeys learn to use tools? Apparently through lessons from mom, according to new findings that suggest education is a very ancient trait in the primate lineage. Long-tailed macaques near an old Buddhist shrine in Lopburi, Thailand, often pull hair from female tourists for use as dental floss. When female monkeys see their young watching them, they exaggerate their flossing. Primatologists at Kyoto University and their colleagues note that such overemphasis is much like what human mothers do when teaching infants, dubbed "motionese" by behavior scientists (after "motherese," or baby talk).

—Charles Q. Choi

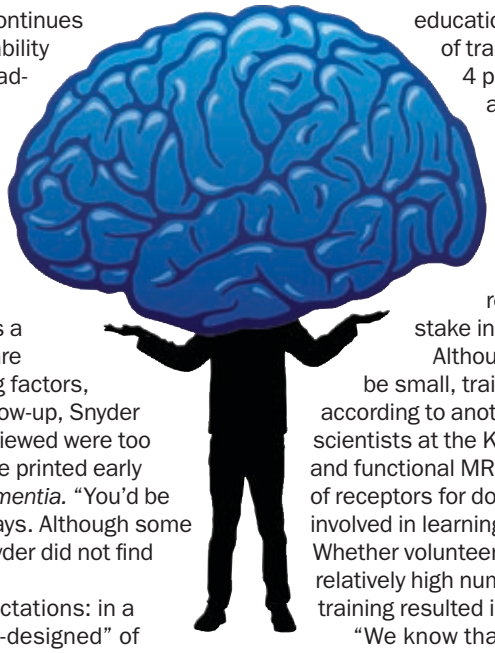
Don't Talk It Out

Too much chat about their problems may lead middle school–age girls into depression, according to a recent study at Stony Brook University. Past research indicates that girls are more likely than boys are to co-ruminate, repeatedly discussing difficulties with friends, speculating about causes and excessively dwelling on negative emotions. In the new study, psychologists confirmed that girls who co-ruminate more often than their peers have more depressive symptoms. They also found a new link with romantic experience: co-rumination was most likely to result in depressive symptoms among girls who were most active romantically. *—Robert Goodier*

>> LEARNING

Brain Training's Unproven Hype

Few studies convincingly show improvements from the popular software



The market for brain-training software continues to grow, but evidence of the programs' ability to boost memory or intelligence in a broadly applicable way (rather than simply making people better at the task they are practicing) remains scarce. New studies offer a tantalizing suggestion that certain programs may work—but the bulk of the research is murky.

Neuroscientist Peter Snyder of Brown University reviewed nearly 20 software studies and concluded that, as a group, they were underwhelming. They are marred by flaws that induce confounding factors, such as a lack of control groups and follow-up, Snyder warns. More than a third of those he reviewed were too shoddy even to include in the analysis he printed early this year in the journal *Alzheimer's & Dementia.* "You'd be surprised at what gets published," he says. Although some products claimed to treat dementia, Snyder did not find any evidence to back such claims.

One paper, however, exceeded expectations: in a new study Snyder called the "most well-designed" of those he evaluated, the Mayo Clinic tested the Brain Fitness Program by Posit Science. [For a review of this and other programs, see "Brain Trainers," by Kaspar Mossman; SCIENTIFIC AMERICAN MIND, April/May/June 2009.] Encouragingly, the researchers found that the software boosted the brain in ways unrelated to the training. Rather than simply learning to parrot back what they had practiced, participants improved their test scores across a range of brain functions, says clinical neuropsychologist Glenn Smith, who led the study.

People who used the program bolstered their working memory—the system that holds information in mind momentarily in tasks such as dialing phone numbers—and processing speed, two assets that deteriorate with age.

Still, the boost was minimal. Subjects who played improved their memory by twice as much as did those in the control group (who spent an equal amount of time watching educational documentaries). After eight weeks of training, that improvement was only about 4 percent. Small effects such as those are a hallmark of brain-training software studies, Snyder says. He adds, however, "This is a good first study to emerge out of a terribly messy literature," and he would like to see if it can be replicated. Posit Science funded the study, but none of the researchers involved has a financial stake in the company.

Although the magnitude of improvement may be small, training's effect on the brain is visible, according to another recent study. In February neuroscientists at the Karolinska Institute in Sweden used PET and functional MRI scans to reveal changes in the number of receptors for dopamine—a chemical messenger involved in learning, among other important functions. Whether volunteers started with a relatively low or relatively high number of dopamine receptors, brain training resulted in a shift closer to the optimum balance.

"We know that the brain is plastic," says Torkel Klingberg, the lead neuroscientist for the investigation. "But nobody has shown that the biochemistry of the brain is plastic in this way." He developed the program used in the study, called Cogmed Working Memory Training, and he has shares in the company.

Snyder praised Klingberg's study but also pointed out that it is a given that the brain will change in response to a variety of interventions. From his perspective, software companies remain hard-pressed to prove their products do much, especially over the long term, and few programs have demonstrated the flexibility to boost skills that were not practiced.

The best memory enhancer is exercise, Snyder says. [For more on exercise and the brain, see "Fit Body, Fit Mind?" on page 24.] Secondarily, a good diet and an active social life have brain benefits. Does software improve on those standbys, he asks? "Frankly, I have my doubts. The evidence isn't in."

—Robert Goodier

Practice Removes Prejudice

Like it or not, most people hold subconscious stereotypes about individuals of races other than their own. New research found a link between such implicit (unconscious) bias and the "other-race effect"—the fact that we can distinguish faces of our own race better than other-race faces. In the study, Caucasians' implicit bias toward African-Americans diminished after they learned to individuate faces of that race.

The other-race effect is not the cause of implicit racial bias, but it prevents us from overcoming our preconceived notions, says lead author Sophie Lebrecht. Only after learning to tell other-race faces apart can we "start to break down these stereotypes."

—Nicole Branan

JULIE FELTON *iStockphoto (brain)*; ISTOCKPHOTO *(body)*; SHANE OBRIEN *iStockphoto (faces)*

>> NEUROSCIENCE

Neuron Cannibalism

Starvation brings out sex differences in brain cells

Scientists have long known of dissimilarities in anatomy and activity between the brains of women and men—now a rodent study shows that even individual neurons behave differently depending on sex.

Robert Clark of the University of Pittsburgh School of Medicine and his colleagues found that cultured neurons from female rats and mice survived longer than did neurons from their male counterparts when facing starvation. Such sex differences had been evident for decades in other body tissues, but so far no one had looked at brain cells, Clark says. When he and his team deprived the cells of nutrients, female neurons consumed mainly fat resources to stay alive, whereas large amounts of male cells started to eat up their own protein-based building blocks—and subsequently died.

The findings suggest that tailoring nutrition to a patient's gender during critical care—for example, after illnesses that temporarily cut off the brain's nutrient supply, such as stroke—might help prevent brain cell death, Clark posits. Men's neurons might fare better on a high-protein diet, for instance, whereas high fat content would probably nourish women's brain cells best, he adds.

Self-cannibalism makes sense for body tissues other than the brain, but why male neurons engaged in it to such a large extent is a mystery, Clark says. "You can understand why during famine, you would want to break down muscle to preserve the rest of your body, but it's harder to understand why you would want to break down proteins within your brain." —*Nicole Branan*

>> EMOTION

Deadly Sin or Social Lubricant?

Feeling proud makes people more dominant and likable in social tasks

Think back to the last time that you beat a friend at a card game or outdid your previous record in a 5K race. Did you try to suppress your satisfaction so that others wouldn't think you were conceited? In fact, new research suggests that pride, as long as it stems from a real success and doesn't slide into know-it-all obnoxiousness or narcissism, not only pushes us to keep trying hard but actually makes others like us more.

"Contrary to the idea that pride is an emotion that we should tamp down, the experience of pride can be very socially adaptive," says Lisa Williams, a graduate student in psychology at Northeastern University and the new study's lead author. She and Northeastern psychologist David DeSteno found that people who were told they had excelled on a spatial rotation task subsequently took more control over a similar, team-based task, regardless of their mood or how competent they reported feeling. Both teammates and outside observers rated proud participants as more dominant and as more likable than participants who had not been tricked into feeling proud.

The study did not examine the signals proud people send that make others like them, but other research has shown that feeling pleased with yourself tends to change a person's subtle nonverbal behaviors—for example, triggering more smiling or a more confident posture.

—*Siri Carpenter*

PAUL COWAN *iStockphoto (steak)*; ISTOCKPHOTO *(butter)*; AGE FOTOSTOCK *(work colleagues)*

>> COGNITION

The Load of Lying

Giving suspects an extra task helps to separate the liars from the truth tellers

We may think we know the telltale signs of lying, be it shifty eyes or nervous fidgeting. Professional interrogators look for such tells, too, assuming a suspect's nervousness betrays his guilt. But interrogation can rattle even the innocent, so nervousness alone cannot distinguish liars from truth tellers.

Scientists looking for better ways to detect lies have found a promising one: increasing suspects' "cognitive load." For a host of reasons, their theory goes, lying is more mentally taxing than telling the truth. Performing an extra task while lying or telling the truth should therefore affect the liars more.

To test this idea, deception researchers led by psychologist Aldert Vrij of the University of Portsmouth in England asked one group to lie convincingly and another group to tell the truth about a staged theft scenario that only the truth tellers had experienced. A second pair of groups had to do the same but with a crucial twist: both the liars and the truth tellers had to maintain eye contact while telling their stories.

Later, as researchers watched videotapes of the suspects' accounts, they tallied verbal signs of cognitive load (such as fewer spatial details in the suspects' stories) and nonverbal ones (such as fewer eyeblinks). The eyeblinks are particularly interesting because whereas rapid blinking suggests nervousness, fewer blinks are a sign of cognitive load, Vrij explains—and contrary to what police are taught, liars tend to blink less. Although the effect was subtle, the instruction to maintain eye contact did magnify the differences between the truth tellers and the liars.

So do these differences actually make it easier for others to distinguish liars from truth tellers? They do—but although students watching the videos had an easier time spotting a liar in the eye-contact condition, their accuracy rates were still poor. Any group differences between liars and truth tellers were dwarfed by differences between individual participants. (For example, some people blink far less than others whether or not they are lying—and some are simply better able to carry a higher cognitive load.)

All this makes it hard to put the study's findings into practice—especially out in the field, where the people most likely to lie are those who are good at lying. "In the real world, there's no Pinocchio-like cue that distinguishes liars from truth tellers," says study co-author Ronald Fisher of Florida International University. Magnifying subtle differences may be the next best thing. [For more on lie detection, see "Portrait of a Lie," by Matthias Gamer; SCIENTIFIC AMERICAN MIND, February/March 2009.]

—*Marina Krakovsky*

LARS TOPELMANN *Jupiterimages (lying)*; THOMAS DEERINCK, NCMIR *Photo Researchers, Inc. (Alzheimer's)*

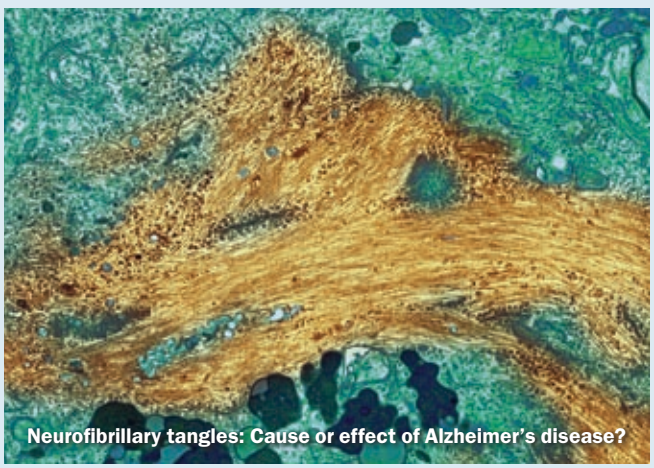
>> DISEASE

Alternative Ideas about Alzheimer's

What if the characteristic plaque in the brain does not actually cause the disease?

With dementia, Alzheimer's disease brings amyloid plaques—proteins that accumulate in the brain. Many scientists believe the plaques are responsible for gradually destroying memory and brain functions. Most research—and most attempts at early diagnosis and treatment—depends on that supposition being correct. But new imaging technologies, which can show plaque buildups in the brains of living subjects, have produced a paradox: some people with plaque remain cognitively intact. A small minority of researchers think this finding suggests a different culprit behind Alzheimer's: oxidative stress.

About 10 to 40 percent of cognitively intact people have been shown to have the same amyloid plaques found in autopsies of Alzheimer's patients but show no signs of the disease. That observation raises two possibilities: either the disorder grows so slowly that these people are just in an early phase of the disease and eventually will show symptoms, or the accepted theory is wrong. Most researchers are convinced it is the former—Alzheimer's can take a decade to grow to severity. That belief is based on years of research, but the way the disease progresses



Neurofibrillary tangles: Cause or effect of Alzheimer's disease?

>> SOCIOLOGY

Popularity Genes

The size and structure of a person's social network have roots in DNA

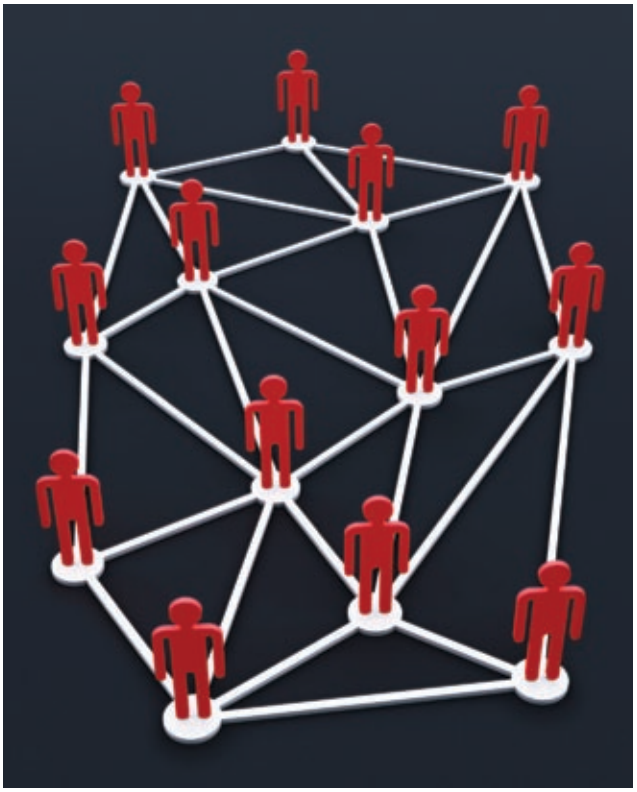
We take it for granted that certain aspects of our social behavior—whether we chat easily with strangers at a party, for instance, or prefer to be a wallflower—are influenced by genetics. But now researchers at the University of California, San Diego, and Harvard University have shown that genes have a much broader sway, affecting the kinds of social networks people form and the positions they occupy in them.

James Fowler, a political scientist at U.C.S.D., and his colleagues studied the social networks of 1,110 adolescent fraternal and identical twins. They found that three aspects of the twins' social networks appeared to be shaped by genetics. How many times each teen was named by others as a friend and how likely each youth's friends were to know one another were both approximately 50 percent related to genetic factors. Whether a teen was located at the center of a network or toward the edge was about 30 percent genetic.

"We have innate characteristics that give us a tendency to gravitate toward one part of a network," Fowler explains. "We vary in the tendency with which we'll attract people as friends, and we vary in our tendency to introduce our friends to one another." The genetic foundation uncovered in the study, he posits, is probably a broad combination of genes that are mostly linked to personality traits such as humor, generosity or extroversion.

Fowler and his co-authors have previously shown that health-related traits and behaviors, including obesity and smoking, seem to spread through social networks—people whose close friends gain weight, for example, are likely to bulk up themselves. Now that the researchers have shown that social networks have a genetic component, they are moving on to the next question: Is it possible that certain genes associated with obesity are not acting directly on the body but are influencing the structure of someone's social network in a way that makes that person more likely to "catch" obesity? "Social networks might be a conduit through which genes act," Fowler says. "It's a pretty big and speculative hypothesis, but this is the first step."

—Emily Anthes



GETTY IMAGES (*social network*)

still has not been nailed down, because until now the only way to definitively diagnose Alzheimer's (as opposed to other kinds of dementia) was by an autopsy after the patient had died.

One puzzling study at the University of California, Berkeley, revealed in November 2008 that Alzheimer's patients, on average, did have higher levels of amyloid than normal controls, but there was overlap. Some of the controls had more amyloid than some patients yet showed none of the symptoms of Alzheimer's. Other studies, including research at Harvard University, reported in December 2008, did uncover a slight decline in memory in cognitively intact subjects with amyloid buildup over time. The Harvard study lasted only one year, however, and the changes in memory were slight. One type of memory decline was related to an increase in amyloid, but correlation alone does not imply causation—again, ambiguous results.

If the amyloid does not cause Alzheimer's, what does? Dissenters to the accepted paradigm think it may be oxidative stress, the wear and tear caused when the body cannot dispose of excess reactive oxygen, which damages cells. The process happens normally as we age. In this theory, the amyloid buildup is more a result of the disease than the cause. Mark A. Smith, a pathologist at Case Western Reserve University and a leading proponent of the oxidative stress theory, says that almost all 80-year-olds have the pathology of Alzheimer's—plaque and tangles—but most of these seniors do not have the disease. A 50-year-old with Alzheimer's might have less amyloid than an 80-year-old without symptoms. "If you are 50 and have five plaques and five tangles, you probably have Alzheimer's," he says. "If you are 70, you need significantly more" for a diagnosis. Smith thinks the amyloid and tangles may be scarring caused by the disease or the body's way of compensating for the oxidative stress—an explanation, he confesses, that is "heresy" to most of his colleagues.

Data confirm that Alzheimer's patients show signs of oxidative stress. If the alternative hypothesis is borne out, antioxidants such as vitamins C and E at least ought to slow the progression of the disease. The only test to date, in which subjects were given vitamin E, failed to show any positive results. Smith points out, however, that the researchers may not have used enough of the vitamin, which is not a particularly good antioxidant and did not lower oxidative stress in the study. Another possibility, he admits, is that the oxidation theory is wrong. Smith thinks the jury is still out, but he urges his colleagues following the amyloid theory to keep at it: "I could be wrong."

—Joel Shurkin

>> SUBSTANCES

Coffee Breakdown

A new study shows a link between caffeine and hallucinations

Have you ever heard a song when none was playing, clearly seen someone's face when no one was there or felt the presence of a person, only to turn around to an empty room? If you've consumed a lot of caffeine—the equivalent to seven cups of coffee—you are three times more likely to hear voices than if you had kept your caffeine intake to less than a cup of coffee, according to psychologists at the University of Durham in England. Their recent study shows that overingesting the stimulant slightly increases your risk of experiencing other hallucinations as well.

Caffeine heightens the physiological effects of stress, lead author Simon Jones says. When someone feels anxiety, the body releases the hormone cortisol, and when people drink plenty of caffeine-infused tea, coffee or soda, their body produces more of the hormone when they encounter stressful events. Researchers have proposed that cortisol may trigger or exaggerate psychotic experiences by increasing the amount of the neurotransmitter dopamine flowing into the brain's limbic areas, evolutionarily ancient regions involved in emotion, memory and behavior.

"The prevalence of hallucinations is probably greater than people would expect," Jones says. Research shows that every year about 5 to 10 percent of people—many of whom do not suffer from mental illness—experience delusions such as hearing voices and seeing things that are not there. According to Jones, "a range of people have frequent hallucinations yet cope well with these experiences."

More research needs to be done before we can directly attribute hallucinations to caffeine; it is possible that people who already see, hear or feel these illusions may be consuming more caffeine for some other, as yet unknown reason, such as self-medication. Jones and other scientists also plan to look at whether nutritional influences such as sugar and fat might play a role in triggering phantom sights and sounds. *—Susan Cosier*

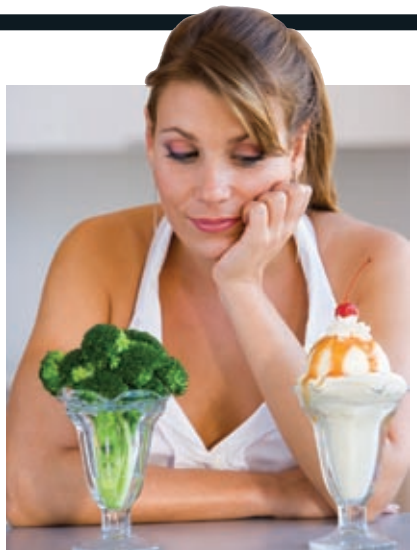
>> PSYCHOLOGY

Waning Willpower

Observing others' self-control can sap one's own

Mentally simulating another person's efforts to use self-control may trick your brain's "fuel gauge" into mistakenly thinking that your own resources have been depleted, a new study suggests. "We're not as individual as we might like to think," says Yale University psychologist Joshua Ackerman. "Often how we understand the world is by relying on the understanding of other people."

If your friend scratches her eyebrow or crosses her arms, studies suggest, odds are you'll unthinkingly mimic the gesture. In the same way, research has shown, goals are also contagious: seeing another person pursue a goal—say, thwarting the urge to have one more Girl Scout cookie—automatically activates the same goal in one's own mind. And neuroimaging studies indicate that mentally simulating another person's experience triggers the same sensory and emotional brain pathways that are activated when one actually performs the action. For example, watching a video of someone about to cut her finger with a kitchen knife triggers brain areas involved in pain perception.



If you imagine yourself in this woman's shoes, your willpower may be depleted.

Ackerman and his colleagues reasoned that if we are wired to treat others' actions as though they are our own, then stepping into the shoes of someone who is exerting self-control should deplete one's own mental resources, just as exerting willpower oneself does. They found that subjects who took the perspective of a hungry restaurant waiter who had to resist the temptation to eat on the job were more vulnerable to impulse spending than subjects who merely read about the waiter.

In the real world, where no one is instructing you to take another's point of view, such vicarious effects are most likely when we are around people who are similar to us or whom we like, Ackerman suspects. University of Minnesota psychologist Kathleen Vohs agrees: "The default way of seeing the world is through one's own eyes. It takes energy and motivation to overcome one's egocentrism." *—Siri Carpenter*

CHIP SIMONS Getty Images (coffee); CARLOS DAVILA Getty Images (willpower)

>> DIET

Forget the Fructose

The sugar may impair memory

Americans consume more fructose than ever before, yet concerns remain that the sugar, used to sweeten beverages and processed foods, poses health risks. In animals, fructose-rich diets increase the production of fat and promote resistance to the energy-regulating hormone insulin. New research suggests that memory suffers as well, at least in rats.

Neuroscientist Marise B. Parent of Georgia State University and her colleagues fed 11 adolescent rats a diet in which fructose supplied 60 percent of the calories. For 10 other rats, cornstarch took the place of the sweetener. The scientists trained the rats to find a submerged platform in a pool, with the help of surrounding cues.

Two days after the training ended, Parent's group removed the pool's platform and recorded where the rats—now adults—swam. Whereas the control group spent most of its time around the platform's old location, the fructose-fed rats visited this area significantly less often. "They can learn" the platform's location, Parent notes, "but they just can't remember it for long periods."

Another research group has shown in hamsters that insulin resistance can affect the hippocampus, a part of the brain critical for learning and remembering facts and events. Parent's team is examining whether the hippocampus of the memory-impaired rats became resistant to the hormone. Parent is also interested in how the addition of glucose, another sugar, would affect her results. The body metabolizes fructose and glucose differently, she explains. People tend to consume both sweeteners at the same time, as high-fructose corn syrup (which is most commonly 55 percent fructose and 45 percent glucose) and table sugar (half fructose and half glucose), and glucose aids the body's absorption of fructose.

—Aimee Cunningham

>> GENETICS

Shaking Hands

Researchers uncover the roots of essential tremor

If your hands and arms quiver when you write and do other tasks, you may have a common neurological condition called essential tremor (ET). As many as 7 percent of adults older than 65 suffer from ET, which may also affect the head and voice. In severe cases, it can be disabling. The cause of such shaking has long been mysterious. But researchers are beginning to uncover a biological explanation for the problem: they have found a gene that may contribute to its development as well as a pathological signature of the disorder in the brain.

Researchers knew that genetic factors underlie ET, as half or more of the cases run in families. But no one until now had succeeded in nabbing any of the responsible genes. To find such a gene, scientists at deCODE genetics in Iceland compared DNA blueprints from hundreds of tremor patients and thousands of unafflicted residents. In each person's DNA, researchers looked at 305,624 single-nucleotide polymorphisms (SNPs), sites where the identity of the chemical unit (the pair of molecules that makes up each building block of a strand of DNA) commonly varies among people. Out of that analysis emerged one SNP that consistently differed between the patients and the others. The same chemical unit also turned out to be tied to ET in populations of patients whom the researchers recruited from Germany, Austria and the U.S.

The newly fingered SNP lies in a gene for a protein called LINGO1 that is present only in the brain and spinal cord—a distribution consistent with a role in neurological disorders, says neurologist Dietrich Haubenberger of the Medical University of Vienna in Austria, one of the study's authors. The protein, which straddles the cell membrane, is thought to govern interactions among cells and to thereby influence neuronal integrity as well as function. LINGO1 also has been implicated in multiple sclerosis and Parkinson's disease, but its precise role in these disorders and in ET is unclear.

Nevertheless, in the case of ET, some researchers theorize that variation in LINGO1 may preferentially affect cells in the brain's cerebellum, a brain structure that edits rough motor programs to produce coordinated movements. Neurologist Elan Louis of Columbia University and his colleagues recently reported seeing degeneration within the brain's cerebellum among individuals who had ET when they were alive. Such deterioration may reduce the quality of the motion editing in that brain structure, leading to tremors, Louis says.

Whatever LINGO1's role in ET, the newly identified version of the gene does not by itself cause the disorder. Having one copy of the risky variant boosts a person's chances of developing ET by 55 percent; having two copies confers a 140 percent greater risk—and the SNP contributes to the condition in only a fifth of cases. But although many more genes, along with external culprits, are likely to be involved, implicating the gene for LINGO1 in ET is an important step toward unraveling the roots of the condition.

Scientists hope that the emerging genetic and cellular story of ET ends with better treatments; today's medications for the disorder are partially effective at best. "Studies like these that start to clarify the biology will form the basis of more biologically based therapies than we have today," Louis predicts.

—Ingrid Wickelgren

CORBIS (*woman*); DANIEL LOISELLE /*Stockphoto* (*cake*); OSCAR BURRIEL *SPL/Photo Researchers, Inc.* (*shaking hands*)

You Are What You Say

A language analysis program reveals personality, mental health and intent by counting and categorizing words

BY JAN DÖNGES

NO ONE DOUBTS that the words we write or speak are an expression of our inner thoughts and personalities. But beyond the meaningful content of language, a wealth of unique insights into an author's mind are hidden in the style of a text—in such elements as how often certain words and word categories are used, regardless of context.

It is how an author expresses his or her thoughts that reveals character, asserts social psychologist James W. Pennebaker of the University of Texas at Austin. When people try to present themselves a certain way, they tend to select what they think are appropriate nouns and verbs, but they are unlikely to control their use of articles and pronouns. These small words create the style of a text, which is less subject to conscious manipulation.

Pennebaker's statistical analyses have shown that these small words may hint at the healing progress of patients and give us insight into the personalities and changing ideals of public figures, from political candidates to terrorists. "Virtually no one in psychology has realized that low-level words can give clues to large-scale behaviors," says Pennebaker, who, with colleagues, developed a computer program that analyzes text, called Linguistic Inquiry and Word Count (LIWC, pronounced "Luke"). The software has been used to examine other speech characteristics as well, tallying up nouns and verbs in hundreds of categories to expose buried patterns.

Character Count

Most recently, Pennebaker and his colleagues used LIWC to analyze the candidates' speeches and interviews during last fall's presidential election. The software counts how many times a speaker or author uses words in specific categories, such as emotion or perception, and words that indicate complex cognitive processes. It also tallies up so-called function words such as pronouns, articles, numerals and conjunctions. Within each of these major categories are subsets: Are there more mentions of sad or happy emotions? Does the speaker prefer "I" and "me" to "us" and "we"? LIWC answers these quantitative questions; psychologists must then figure out what the numbers mean. Before LIWC was developed in the mid-1990s, years of psychological research in which people counted words by hand established robust connections between word usage and psychological states or character traits [*see box on opposite page*].

The political candidates, for example, showed clear differences in their speaking styles. John McCain tended to speak directly and personally to his constituency, using a vocabulary that was both emotionally loaded and impulsive. Barack Obama, in contrast, made frequent use of causal relationships, which indicated more complex thought processes. He also tended to be more vague than his Republican rival. Pennebaker's team has posted a far more in-depth breakdown, including analyses of the vice presidential candidates, at www.wordwatchers.wordpress.com.

Skeptics of LIWC's usefulness point out that many of these characteristics of McCain's and Obama's speeches could be gleaned without the use of a computer program. When the subjects of analysis are not accessible, however, LIWC may provide a unique insight. Such was the case with Pennebaker's study of

> Virtually no one in psychology has realized that low-level words can give clues to **large-scale behaviors**.

JUPITERIMAGES

al Qaeda communications. In 2007 he and several co-workers, under contract with the FBI, analyzed 58 texts by Osama bin Laden and Ayman al-Zawahiri, bin Laden's second in command.

The comparison showed how much pronouns are able to disclose. For example, between 2004 and 2006 the frequency with which al-Zawahiri used the word "I" tripled, whereas it remained constant in bin Laden's writings. "Normally, higher rates of 'I' words correspond with feelings of insecurity, threat and defensiveness. Closer inspection of his 'I' use in context tends to confirm this," Pennebaker says.

Other studies have shown that words that are used to express balance or nuance ("except," "but," and so on) are associated with higher cognitive complexity, better grades and even the truthfulness with which facts are reported. For bin Laden, analysis showed that the thought processes in his texts had reached a higher level over the years, whereas those of his lieutenant had stagnated.

Healing Words

This power of statistical analysis to quantify a person's changing language use over time is a key advantage to programs such as LIWC. In 2003 Pennebaker and statistician R. Sherlock Campbell, now at Yale University, used a statistical tool called latent semantic analysis (LSA) to study the diary entries of trauma patients from three earlier studies, looking for text characteristics that had changed in patients who were convalescing and met rarely with their physician. Again, the researchers showed that content was unimportant. The factor that was most clearly associated with recovery was the use of pronouns. Patients whose writings changed perspective from day to day were less likely to seek medical treatment during the follow-up period.

It may be that patients who describe their situation both from their own viewpoint and from the perspective of others recover more quickly from traumatic experiences—a variation on the already well-established idea that writing about negative experiences is therapeutic. Or perhaps the LSA simply detected the patients' recovery as reflected by their writing but not brought about by it—in that case, programs such as LIWC could aid doctors in diagnosing illness and gauging treatment progression. Researchers are currently investigating many other patient groups, including those with cancer, mental illness and suicidal tendencies, using LIWC to uncover clues about their emotional well-being and their mental state.

Although the statistical study of language is relatively young, it is clear that analyzing patterns of word use and writing style can lead to insights that would otherwise remain hidden. Because these tools offer predictions based on probability, however, such insights will never be definitive. "In the final analysis, our situation is much like that of economists," Pennebaker says. "It's too early to come up with a standardized analysis. But at the end of the day, we all are making educated guesses, the same way economists can understand, explain and predict economic ups and downs." M

JAN DÖNGES is a linguist and science journalist in Heidelberg, Germany.

He Said, She Said

The way we write and speak can reveal volumes about our identity and character. Here is a sampling of the many variables that can be detected in our use of style-related words such as pronouns and articles:

>> **Gender:** In general, women tend to use more pronouns and references to other people. Men are more likely to use articles, prepositions and big words.

>> **Age:** As people get older, they typically refer to themselves less, use more positive-emotion words and fewer negative-emotion words, and use more future-tense verbs and fewer past-tense verbs.

>> **Honesty:** When telling the truth, people are more likely to use first-person singular pronouns such as "I." They also use exclusive words such as "except" and "but." These words may indicate that a person is making a distinction between what they did do and what they did not do—liars often do not deal well with such complex constructions.

>> **Depression and suicide risk:** Public figures and published poets use more first-person singular pronouns when they are depressed or suicidal, possibly indicating excessive self-absorption and social isolation.

>> **Reaction to trauma:** In the days and weeks after a cultural upheaval, people use "I" less and "we" more, suggesting a social bonding effect.

Adapted from http://homepage.psy.utexas.edu/homepage/faculty/pennebaker/Home2000/Words.html

(Further Reading)

- **The Secret Life of Pronouns: Flexibility in Writing Style and Physical Health.** R. Sherlock Campbell and James W. Pennebaker in *Psychological Science,* Vol. 14, No. 1, pages 60–65; January 2003.
- **Computerized Text Analysis of Al-Qaeda Transcripts.** James W. Pennebaker and Cindy K. Chung in *The Content Analysis Reader.* Edited by Klaus Krippendorff and Mary Angela Bock. Sage Publications, 2007.
- A detailed description of LIWC's development and uses, as well as the software itself (available for sale), can be found at **www.liwc.net/liwcdescription.php**

A Theory of Consciousness

Is complexity the secret to sentience, to a panpsychic view of consciousness?

BY CHRISTOF KOCH

DO YOU THINK that your newest acquisition, a Roomba robotic vacuum cleaner that traces out its unpredictable paths on your living room floor, is conscious? What about that bee that hovers above your marmalade-covered breakfast toast? Or the newborn who finally fell asleep after being suckled? Nobody except a dyed-in-the-wool nerd would think of the first as being sentient; adherents of Jainism, India's oldest religion, believe that bees—and indeed all living creatures, small and large—are aware; whereas most everyone would accord the magical gift of consciousness to the baby.

Is iRobot's Roomba robotic vacuum cleaner conscious? How about a bee, a comatose patient or a sleeping baby? Integrated information theory might tell us.

The truth is that we really do not know which of these organisms is or is not conscious. We have strong feelings about the matter, molded by tradition, religion and law. But we have no objective, rational method, no step-by-step procedure, to determine whether a given organism has subjective states, has feelings.

The reason is that we lack a coherent framework for consciousness. Although consciousness is the *only* way we know about the world within and around us—shades of the famous Cartesian deduction cogito, ergo sum—there is no agreement about what it is, how it relates to highly organized matter or what its role in life is. This situation is scandalous! We have a detailed and very successful framework for matter and for energy but not for the mind-body problem. This dismal state of affairs might be about to change, however.

The universal lingua franca of our age is information. We are used to the idea that stock and bond prices, books, photographs, movies, music and our genetic makeup can all be turned into data streams of zeros and ones. These bits are the elemental atoms of information that are transmitted over an Ethernet cable or via wireless, that are stored, replayed, copied and assembled into gigantic repositories of knowledge. Information does not depend on the substrate. The same information can be represented as lines on paper, as electrical charges inside a PC's memory banks or as the strength of the synaptic connections among nerve cells.

Since the early days of computers, scholars have argued that the subjective, phenomenal states that make up the life of the mind are intimately linked to the information expressed at that time by the brain. Yet they have lacked the tools to turn this hunch into a concrete and predictive theory. Enter psychiatrist and neuroscientist Giulio Tononi of the University of Wisconsin–Madison. Tononi has developed and refined what he calls the integrated information theory (IIT) of consciousness.

An Integrated Theory

IIT is based on two axiomatic pillars.

First, conscious states are highly differentiated; they are informationally very rich. You can be conscious of an uncountable number of things: you can watch your son's piano recital, for instance; you can see the flowers in the garden outside or the Gauguin painting on the wall. Think of all the frames from all the movies you have ever seen or that have ever been filmed or that will be filmed! Each frame, each view, is a specific conscious percept.

Second, this information is highly integrated. No matter how hard you try, you cannot force yourself to see the world in black-and-white, nor can you see only the left half of your field of view and not the right. When you're looking

> The truth is that we **really do not know** which of these organisms is or is not conscious.

FATMA IMAMOGLU (*Koch*); TONY CENICOLA *New York Times*/*Redux Pictures* (*Roomba*); AGE FOTOSTOCK (*bee*)

at your friend's face, you can't fail to also notice if she is crying. Whatever information you are conscious of is wholly and completely presented to your mind; it cannot be subdivided. Underlying this unity of consciousness is a multitude of causal interactions among the relevant parts of your brain. If areas of the brain start to disconnect or become fragmented and balkanized, as occurs in deep sleep or in anesthesia, consciousness fades and might cease altogether. Consider split-brain patients, whose corpus callosum—the 200 million wires linking the two cortical hemispheres—has been cut to alleviate severe epileptic seizures. The surgery literally splits the person's consciousness in two, with one conscious mind associated with the left hemisphere and seeing the right half of the visual field and the other mind arising from the right hemisphere and seeing the left half of the visual field.

To be conscious, then, you need to be a single, integrated entity with a large repertoire of highly differentiated states. Although the 60-gigabyte hard disk on my MacBook exceeds in capacity my lifetime of memories, that information is not integrated. For example, the family photographs on my Macintosh are not linked to one another. The computer does not know that the girl in those pictures is my daughter as she matures from a toddler to a lanky teenager and then a graceful adult. To my Mac, all information is equally meaningless, just a vast, random tapestry of zeros and ones.

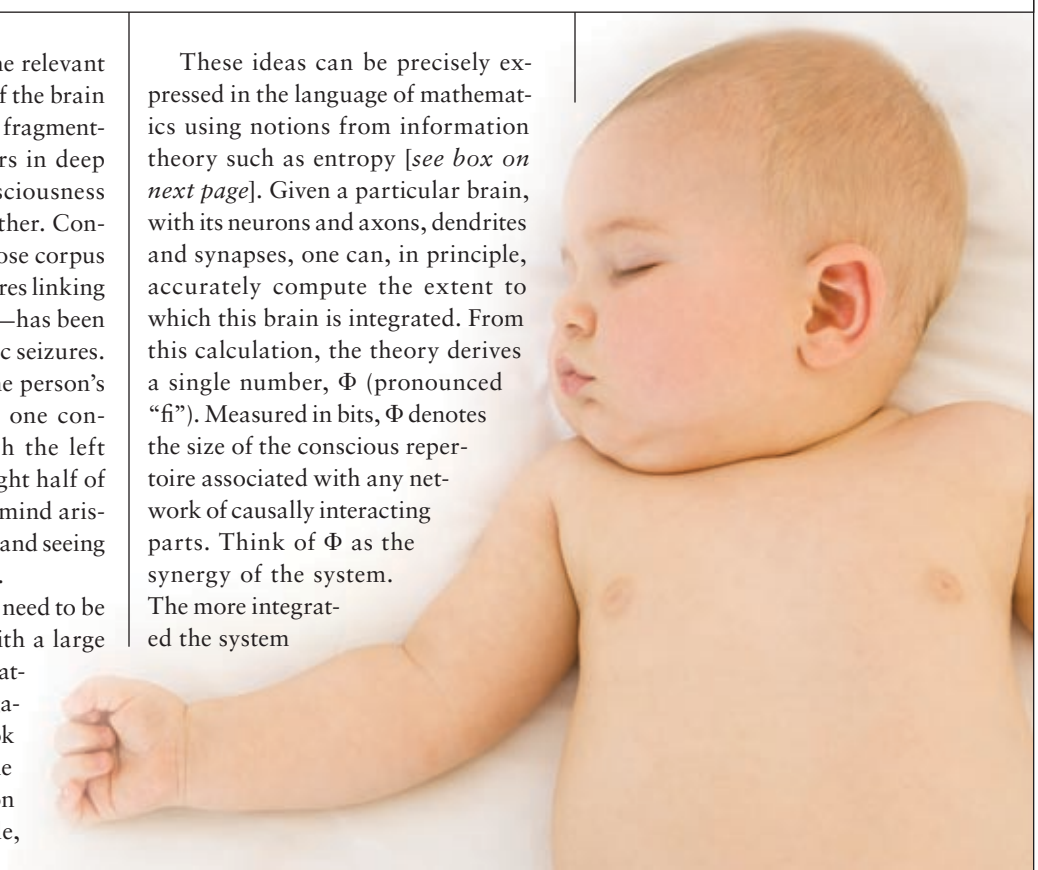
Yet I derive meaning from these images because my memories are heavily cross-linked. And the more interconnected, the more meaningful they become. Indeed, Tononi's IIT postulates that the amount of integrated information that an entity possesses corresponds to its level of consciousness.

These ideas can be precisely expressed in the language of mathematics using notions from information theory such as entropy [*see box on next page*]. Given a particular brain, with its neurons and axons, dendrites and synapses, one can, in principle, accurately compute the extent to which this brain is integrated. From this calculation, the theory derives a single number, Φ (pronounced "fi"). Measured in bits, Φ denotes the size of the conscious repertoire associated with any network of causally interacting parts. Think of Φ as the synergy of the system. The more integrated the system is, the more synergy it has, the more conscious it is. If individual brain regions are too isolated from one another or are interconnected at random, Φ will be low. If the organism has many neurons and is richly endowed with specific connections, Φ will be high—capturing the quantity of consciousness but not the quality of any one conscious experience. (That value is generated by the informational geometry that is associated with Φ but won't be discussed here.)

Explaining Brain Facts

The theory can account for a number of puzzling observations. The cerebellum, the "little brain" at the back of the brain that contains more neurons than the convoluted cerebral cortex that crowns the organ, has a regular, crystallinelike wiring arrangement. Thus, its circuit complexity as measured by Φ is

> To be conscious, you must be a single, integrated entity with **a large repertoire** of highly differentiated states.



AGE FOTOSTOCK (*comatose man*); JUPITERIMAGES (*sleeping baby*)

If you **lose your cerebellum,** you will never be a dancer or pianist, but your consciousness will be unimpaired.

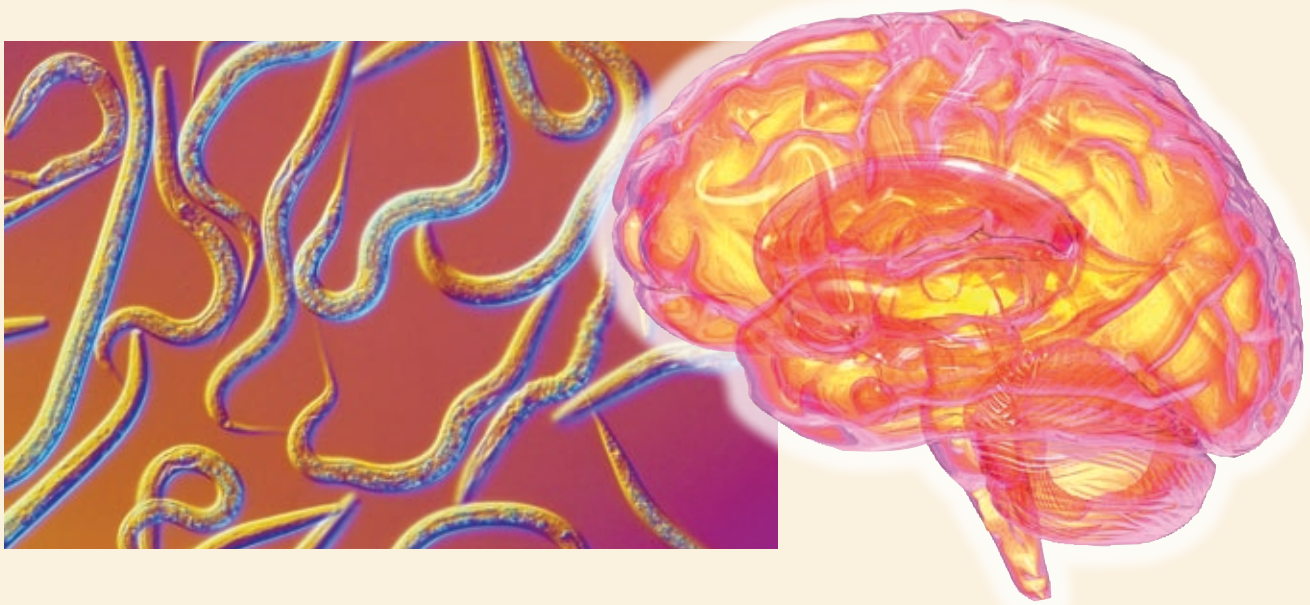
low as compared with that of the cerebral cortex. Indeed, if you lose your cerebellum you will never be a rock climber, pianist or ballet dancer, but your consciousness will not be impaired. The cortex and its gateway, the thalamus—the quail egg–shaped structure in the center of the brain—on the other hand, are essential for consciousness, providing it with its elaborate content. Its circuitry conjoins functional specialization with functional integration thanks to extensive reciprocal connections linking distinct cortical regions and the cortex with the thalamus. This cortico-thalamic complex is well suited to behave as a single dynamic entity endowed with a large number of discriminable states. Lose one chunk of a particular cortical area, and you might be unable to perceive motion. If a different area were lesioned, you would be blind to faces (yet could see the eyes, hair, mouth and ears).

When people are woken from deep sleep, they typically recall experiencing nothing or, at best, only some vague bodily feeling; this experience contrasts with the highly emotional narratives our brains weave during rapid-eye-movement (REM) sleep. What is paradoxical is that the average firing activity of individual nerve cells does not differ that much in deep sleep and quiet wakefulness. At the whole system level, though, electroencephalographic electrodes on the skull pick up slow, large and highly synchronized waves during deep sleep. Because these waves are quite regular, they will disrupt the transfer of specific information among brain cells.

Every day, in tens of thousands of surgical operations, patients' consciousness is quickly, safely and transiently turned off and on again with the help of

How to Calculate Consciousness in All Creatures

Integrated information theory uses mathematics (*bottom*) to quantify the amount of integrated information an entity possesses—and thus its level of consciousness. The challenge: we cannot yet calculate the state of awareness for even the simple roundworm (*left*) with current computers, let alone deal with the complexity of the human brain.



$$ei(x_1; P) = -\sum_{i=1}^{k}\sum_{\mu_0{}^{(i)}} p(\mu_0{}^{(i)}|x_1)\ \log p(\mu_0{}^{(i)}|\mu_1{}^{(i)}) - H(X_0|x_1)$$

$$\Phi(x_1) = \min_{P} \frac{ei(x_1; P)}{\nu_P}$$

SINCLAIR STAMMERS (*roundworms*) AND DAVID MACK (*brain*) *SPL/Photo Researchers, Inc.*

various anesthetic agents. There is no single mechanism common to all. The most consistent regional finding is that anesthetics reduce thalamic activity and deactivate mesial (middle) and parietal cortical regions. Twenty years of electrical recording in anesthetized laboratory animals provided ample evidence that many cortical cells, particularly in primary sensory cortical regions, continue to respond selectively during anesthesia. What appears to be disrupted is large-scale functional integration in the corticothalamic complex.

IIT explains why consciousness requires neither sensory input nor behavioral output, as happens every night during REM sleep, in which a central paralysis prevents the sleeper from acting out her dreams. All that matters for consciousness is the functional relation among the nerve cells that make up the corticothalamic complex. Within this integrated dynamic entity can be found the dream of the lotus eater, the mindfulness of the meditating monk, the agony of the cancer patient and the Arcadian visions of your lost childhood home. Paraphrasing Oscar Wilde, I would say it is the causal interactions within the dynamic core that make the poppy red, the apple odorous and the skylark sing.

Consciousness Is Universal

One unavoidable consequence of IIT is that all systems that are sufficiently integrated and differentiated will have some minimal consciousness associated with them: not only our beloved dogs and cats but also mice, squid, bees and worms.

Indeed, the theory is blind to synapses and to all-or-none pulses of nervous systems. At least in principle, the incredibly complex molecular interactions within a single cell have nonzero Φ. In the limit, a single hydrogen ion, a proton made up of three quarks, will have a tiny amount of synergy, of Φ. In this sense, IIT is a scientific version of panpsychism, the ancient and widespread belief that all matter, all things, animate or not, are conscious to some extent. Of course, IIT does not downplay the vast gulf that separates the Φ of the common roundworm *Caenorhabditis elegans* with its 302 nerve cells and the Φ associated with the 20 billion cortical neurons in a human brain.

The theory does not discriminate between squishy brains inside skulls and silicon circuits encased in titanium. Provided that the causal relations among the transistors and memory elements are complex enough, computers or the billions of personal computers on the Internet will have nonzero Φ. The size of Φ could even end up being a yardstick for the intelligence of a machine.

Future Challenges

IIT is in its infancy and lacks the graces of a fully developed theory. A major question that it so far leaves unanswered is, Why should natural selection evolve creatures with high Φ? What benefit for the survival of the organism flows from consciousness? One answer that I hope for is that intelligence, the ability to assess situations never previously encountered and to rapidly come to an appropriate response, requires integrated information. Another possible answer, though, could be that high-Φ circuits do not have any special status in terms of their survival. Just as electrical charge is a fundamental feature of the universe without a function, consciousness might also lack any specific evolutionary role. It just is.

A second stumbling block with IIT is that Φ is exceedingly difficult to compute even for very small systems. To accurately evaluate Φ for the roundworm is utterly unfeasible, even if using all of Google's more than 100,000 computers. Can we find other algorithms to more easily compute Φ?

A third issue to understand is why so much brain processing and so many of our daily behaviors are unconscious. Do the neural networks that mediate these unconscious, zombielike behaviors have lower Φ than the ones that give rise to consciousness?

Tononi's integrated information theory of consciousness could be completely wrong. But it challenges us to think deeply about the mind-body problem in a novel, rigorous, and mathematically and empirically minded manner. And that is a great boon to this endeavor.

> The theory **does not discriminate** between squishy brains inside skulls and silicon circuits encased in titanium.

If Tononi's equation for Φ proves to plumb the hitherto ineffable—consciousness itself—it would validate the ancient Pythagorean belief that "number is the ruler of forms and ideas and the cause of gods and demons." M

CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology and serves on *Scientific American Mind*'s board of advisers.

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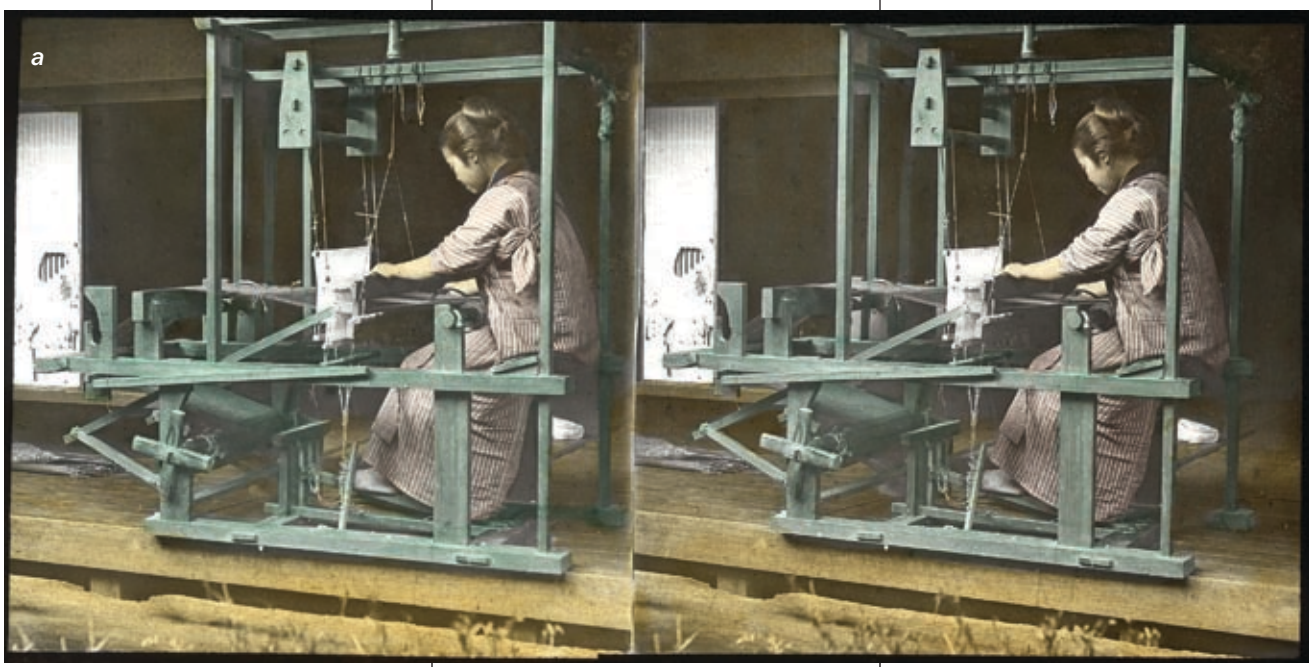
- **Integrated Information in Discrete Dynamical Systems: Motivation and Theoretical Framework.** David Balduzzi and Giulio Tononi in *PLoS Computational Biology,* Vol. 4, No. 6; June 2008.
- **Consciousness as Integrated Information: A Provisional Manifesto.** Giulio Tononi in *Biological Bulletin,* Vol. 215, No. 3, pages 216–242; December 2008.

Seeing in Stereo

Binocular vision gives us depth perception—and enables us to play some tricks

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN



ALL PRIMATES, including humans, have two eyes facing forward. With this binocular vision, the views through the two eyes are nearly identical. In contrast, many other animal groups, especially herbivores such as ungulates (hooved animals, including cows, sheep and deer) and lagomorphs (rabbits, for example), have eyes pointing sideways (*b*). This perspective provides largely independent views for each eye and an enormously enlarged field of view overall. Why did primates sacrifice panoramic vision? What benefit did they gain?

We know binocular vision evolved several times independently in vertebrates. For example, among birds, predatory species such as owls and hawks have forward-pointing eyes (*c*). One theory is that the feature conferred a statistical advantage—two eyes are better than one—for detecting and discriminating objects, such as prey, in low light levels. But whatever the original reason for its emergence, the evolutionary novelty afforded a huge advantage: stereoscopic (literally, solid) vision.

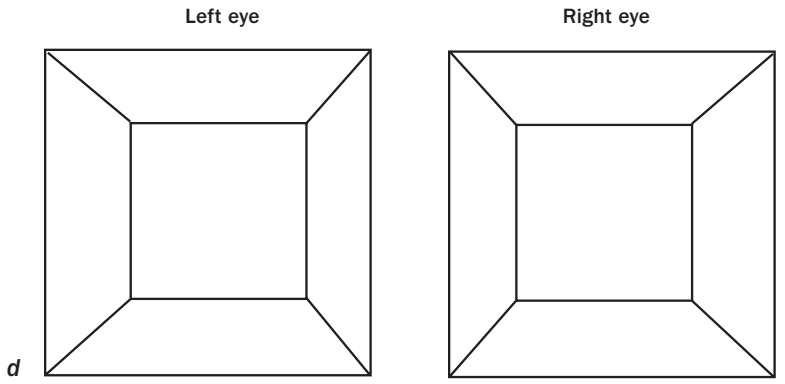
Shifting Views

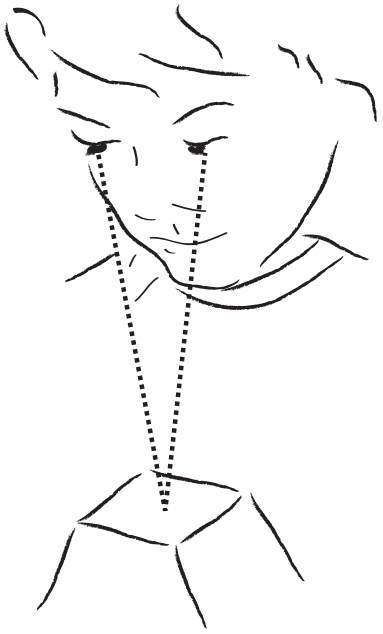
How does it work? Even though both your eyes point forward, they are separated horizontally so that they look at the world from two slightly different vantage points. It follows that each eye receives a slightly different picture of the three-dimensional scene around you; the differences (called retinal disparities) are proportional to the relative distances of the objects from you. Try this quick experiment to see what we mean: hold two fingers up, one in front of the other. Now, while fixating on the closer finger, alternately open and close each eye. You'll notice that the farther the far finger is from you (don't move the near finger), the greater the lateral shift in its position as you open and close each eye. On the retinas, this difference in line-of-sight shift manifests itself as disparity between the left and right eye images.

A simplified example shows this effect clearly (*d*). When you look at the pyramid, the right eye sees more of the right side than the left eye does, and vice versa; it is a simple consequence of geometric optics. Notice that the images in the two eyes are correspondingly different; the inner square is shifted right or

ROGER VIOLLET *Getty Images (stereo images)*; TIM FITZHARRIS *Minden Pictures (hippo)*; ANDY ROUSE *Corbis (owl)*

Side-pointing eyes give an enormously enlarged field of view. Why did primates sacrifice panoramic vision?





SCIENTIFIC AMERICAN MIND (*pyramids*); SOURCE: *ILLUSION IN NATURE AND ART*, EDITED BY RICHARD LANGTON GREGORY AND ERNST HANS GOMBRICH. DUCKWORTH, 1973 (*illustration of viewer*)

left. This retinal disparity is proportional to the height of the pyramid. The brain measures the difference and experiences it as stereoscopic depth.

Although this explanation seems patently obvious today, it wasn't elucidated until the 19th century. Leonardo da Vinci attempted to explain it several hundred years earlier and correctly observed that because the eyes normally receive different views of a 3-D scene, it is impossible, even in principle, to convey a full sense of 3-D on a 2-D canvas. Leonardo puzzled over how we can see a single world of solid objects given the different eye views (now known as Leonardo's paradox), but he failed to grasp the critical point that retinal disparity is not a problem but is the basis for stereopsis.

This fact was finally made clear in 1838 by English physicist Charles Wheatstone, who published an elegant series of experiments on binocular vision. Recognizing the difference in perspective of the left and right eyes, he began by making line drawings of each eye's view of simple objects. Then, employing a device he invented, called a mirror stereoscope, he presented these line drawings together to the viewer: left view to left eye alone; right view to right eye alone. Imagine his astonishment—and delight!—when he saw the skeletal outline of the object spring into 3-D relief, looking like he could almost reach out and grab it. It must have been the same sense of wonder every child experiences when playing with a stereo viewer such as the familiar View-Master. It seems like magic.

But how exactly does the brain blend the two eyes' slightly different pictures harmoniously into a single fused picture? And how does it measure and extract the differences to allow for seeing in stereo? On one hand, it needs to unify the pictures; on the other hand, it needs to preserve and measure their differences.

Consider what happens when you fixate on an image, such as a letter—the X on this page—with both eyes. Images of the letter project to the central part of each retina (the fovea), and the brain fuses them into one. You see one X, not two. English physiologist Charles Sherrington suggested in the early 20th century that this blending was a mysterious psychological process occurring in the mind, requiring no actual confluence of messages into a single brain area. We must not confuse mental fusion with physiological fusion, he urged.

We now know he was wrong: binocular fusion is a physiological process. The X, or any point on which you fixate, falls on what is, functionally and geometrically, termed corresponding retinal points. In fact, any point from an entire plane (or, strictly speaking, from a slightly curved surface), centered on the fixation point, would stimulate corresponding retinal points and be seen as a single object (any letter on this page, not just the one on which you fixate, appears singly). As neuroscientists David Hubel and Torsten Wiesel of Harvard University discovered in a series of groundbreaking experiments in the 1960s, individual cells in the visual cortex, so-called binocular cells, receive input from both eyes, specifically from corresponding retinal locations, thus providing a mechanism for perceptual fusion.

Yet if binocular neurons were only excited when identical input arrived from both eyes, you would have trouble perceiving real 3-D objects. John "Jack" Pettigrew, then a young medical student in Canberra, Australia, noted this fact in the mid 1960s, reasoning that the neural mechanism for stereopsis must entail another set of binocular neurons, ones that signal retinal disparity by processing noncorresponding retinal points.

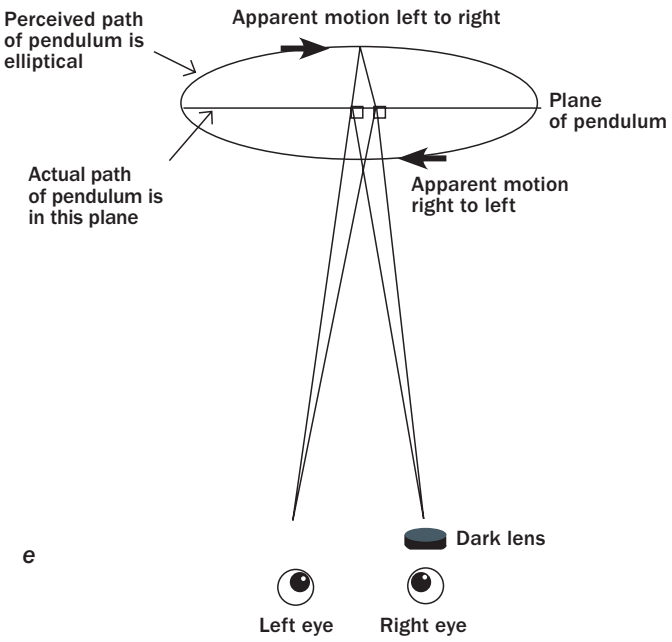
What Pettigrew (along with his colleagues Horace B. Barlow, Colin Blakemore and Peter Bishop) found was that Hubel and Wiesel's description was only partially correct. Sure enough, corresponding points from the retinas send signals that converge on single neurons

It has been a **long journey** from Leonardo, Wheatstone and Victorian parlor toys to modern physiology.

in the visual cortex. It is as if there is a map of each eye's image in the brain, and these maps are in registration (speaking anatomically); that arrangement makes sense overall. But many noncorresponding points also converge on and activate binocular cells. It is these neurons that signal stereo depth because they are, in effect, measuring the horizontal scatter between the left and right eye images. As a consequence, what you have even at this early stage is not a flat 2-D map of the world on the cortex but a 3-D map. This fact was probably the most important discovery about binocular vision since Wheatstone's insight.

Of course, we have progressed much since Wheatstone's days. Instead of drawings, we can mimic the two eyes' views using a camera. Look at any 3-D scene and take one picture from the left eye's vantage point. Then shift the camera to the right eye's location and take a second picture. Print the two photographs, place a vertical partition so that each eye gets only its own image and, lo and behold, the image transforms into a 3-D scene. (See the example at *a*.) Such stereograms were highly popular in Victorian drawing rooms (they were carefully stashed away if they were pornographic, proudly passed around at family gatherings if they were travel series).

The best way to view them is through a stereoscope, which incorporates lenses and prisms or mirrors for more natural accommodation and convergence. But you can try the rudimentary partition method just discussed. With some practice, you can get the eyes aligned to fuse the images and see stereo depth. It is well worth the effort.



e

Pendulum Play

Another stereo illusion you can construct and experience is the Pulfrich effect (*e*), described, ironically, by the famous one-eyed scientist Carl Pulfrich in 1922 (experimenting on others, of course). Hang a weight on the end of an 18-inch string and set it in motion like a pendulum, moving back and forth horizontally in a single plane (its speed gradually accelerates as it approaches the center and decelerates again as it reaches the top at the other end). Now put a filter (sunglasses will do) in front of one eye alone. Astonishingly, you will see the pendulum making an elliptical 3-D excursion toward and away from you! With a left eye filter, motion will be clockwise, as seen from above; counterclockwise with a right eye filter. And the darker your glasses, the greater the depth of the ellipse you will see. Remove the filter, and it goes back to the 2-D swing of a regular pendulum.

The effect occurs because the filter reduces the luminance of the pendulum on the one retina, producing a slight delay in transmission to the binocular cells in the visual cortex. This delay means the pendulum's dim image is "assumed" by the brain to lag behind spatially—as if noncorresponding points were stimulated—thereby fooling the brain into thinking the pendulum is moving in 3-D. The greater the velocity of the pendulum (for instance, during midflight), the greater the three-dimensionality experienced, hence its elliptical path in 3-D.

It has been a long journey from Leonardo, Wheatstone and Victorian parlor toys to modern physiology and psychophysics, but we have barely begun to understand the subtleties of binocular vision. In the next issue we will explore this theme further. M

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN collaborate on studies of visual perception at the Center for Brain and Cognition at the University of California, San Diego. They serve as members of the board of advisers for *Scientific American Mind*.

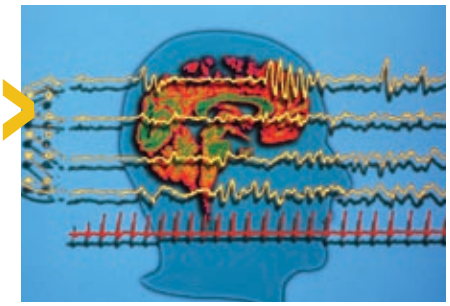
(Further Reading)

- **The Neural Mechanism of Binocular Depth Discrimination.** H. B. Barlow, C. Blakemore and J. D. Pettigrew in *Journal of Physiology,* Vol. 193, pages 327–342; November 1, 1967.
- **The Role of Contours in Stereopsis.** V. S. Ramachandran, V. Madhusudhan Rao and T. R. Vidyasagar in *Nature,* Vol. 242, pages 412–414; April 6, 1973.
- **Seeing in Depth.** Ian P. Howard and Brian J. Rogers. Oxford University Press, 2008.

(calendar)

July

9 On this day in 1934, Canadian scientist Herbert Jasper of Brown University made the first electrical tracing from a human brain. Jasper, considered to be one of the founders of modern neuroscience, pioneered the **use of the electroencephalogram** (EEG) to study electrical activity associated with fundamental brain functions such as consciousness and learning. He and his collaborator, neurosurgeon Wilder Penfield, also elucidated the mechanism underlying epilepsy and invented a highly successful procedure to treat seizures. Their work has contributed largely to our understanding of functional anatomy and lateralization of the human brain.



10 Pop song spoof artist "Weird Al" Yankovic lends his goofy talent to science education as a virtual guide in the **Brainitorium**. At the Orange County Fair, through August 9, he will host a 3-D animated tour of the human brain. The film's finale is a Brainitorium exclusive—Weird Al's first computer-generated music video for a new tune he calls "The Brain Song."
Costa Mesa, Calif.
www.ocfair.com/2009/concert/concert.html

17 Alternative therapies are increasingly used alongside and in conjunction with conventional medicine. Health care professionals will share their expertise in mind-body medicine at the AlterMed Research Foundation's **Colorado Integrative Medicine Conference**. Presentations will address how techniques such as mindfulness, biofeedback and meditation can manage stress and complement traditional treatments.
Estes Park, Colo.
www.altermedresearch.org/Conferences.html

August

6 Advances in genetic research are arguably redefining the field of psychology. In his keynote address at the **117th Annual Convention of the American Psychological Association**, Francis Collins, former director of the National Human Genome Research Institute, will discuss the implications of genetics for behavioral science. Conference participants will discuss new research on timely issues ranging from the war on terror and the current economic crisis to happiness in turbulent times and anger disorders.
Toronto
www.apa.org/convention09

6 The practice of art therapy, often used to aid recovery from trauma and emotional distress, has been strongly influenced by Swiss psychiatrist Carl Jung's belief that visual imagery provides a powerful window into the human experience. Jung emphasized that the psyche could best be understood by exploring not only art but also mythology, dreams and religion. Talks at the **Eighth Annual Conference of the Jungian Society for Scholarly Studies** will cleave closely to Jung's teachings: they will draw on the roles of nature, politics and archetypal images as each intersects with the mind.
Ithaca, N.Y.
www.thejungiansociety.org/Jung%20Society/Conferences/Conference-2009/Conference-2009.html

27 Leon Festinger's ***A Theory of Cognitive Dissonance*** was published on this day in 1957. Cognitive dissonance, one of the most influential and well-studied theories in social psychology, refers to the uncomfortable feeling a person has when he or she holds two contradictory ideas or behaviors at the same time; a classic example involves a smoker who knows the health risks of smoking. The theory asserts that people experience a motivational drive to reduce the dissonance, often not by stopping a behavior but by rationalizing it—using the argument, for instance, that smoking keeps my weight down and that obesity is even worse.

Ongoing

Let Wallace & Gromit, the animated duo responsible for kooky contraptions and oddball business schemes, guide your family through **A World of Cracking Ideas**, an exhibition at London's Science Museum designed to inspire a new generation of innovative minds. Kids can fuel their creative streaks by interacting with real devices that have transformed our daily lives. The exhibit runs through November 1, but youngsters can visit www.crackingideas.com all year-round to enter contests with their own inventions.
London
www.sciencemuseum.org.uk/visitmuseum/galleries/Wallace_and_Gromit.aspx

Are you a good multitasker? Can you read a poker face? Find out at **Mind**, a permanent exhibit at the Exploratorium. A product of four years of collaboration with world-renowned cognitive scientists, this collection of more than 40 interactive stations guarantees you'll learn something new about your mind. If you can't visit in person, the Web site lets you try many of the activities remotely.
San Francisco
www.exploratorium.edu/mind/about/more_about.html

PHANIE/PHOTO RESEARCHERS, INC. (*electroencephalogram*); ELENA DORFMAN *Redux Pictures* (*art therapy*); JUSTIN SUTCLIFFE (*Wallace & Gromit*)

Compiled by Rachel Dvoskin and Robert Goodier. Send items to editors@SciAmMind.com

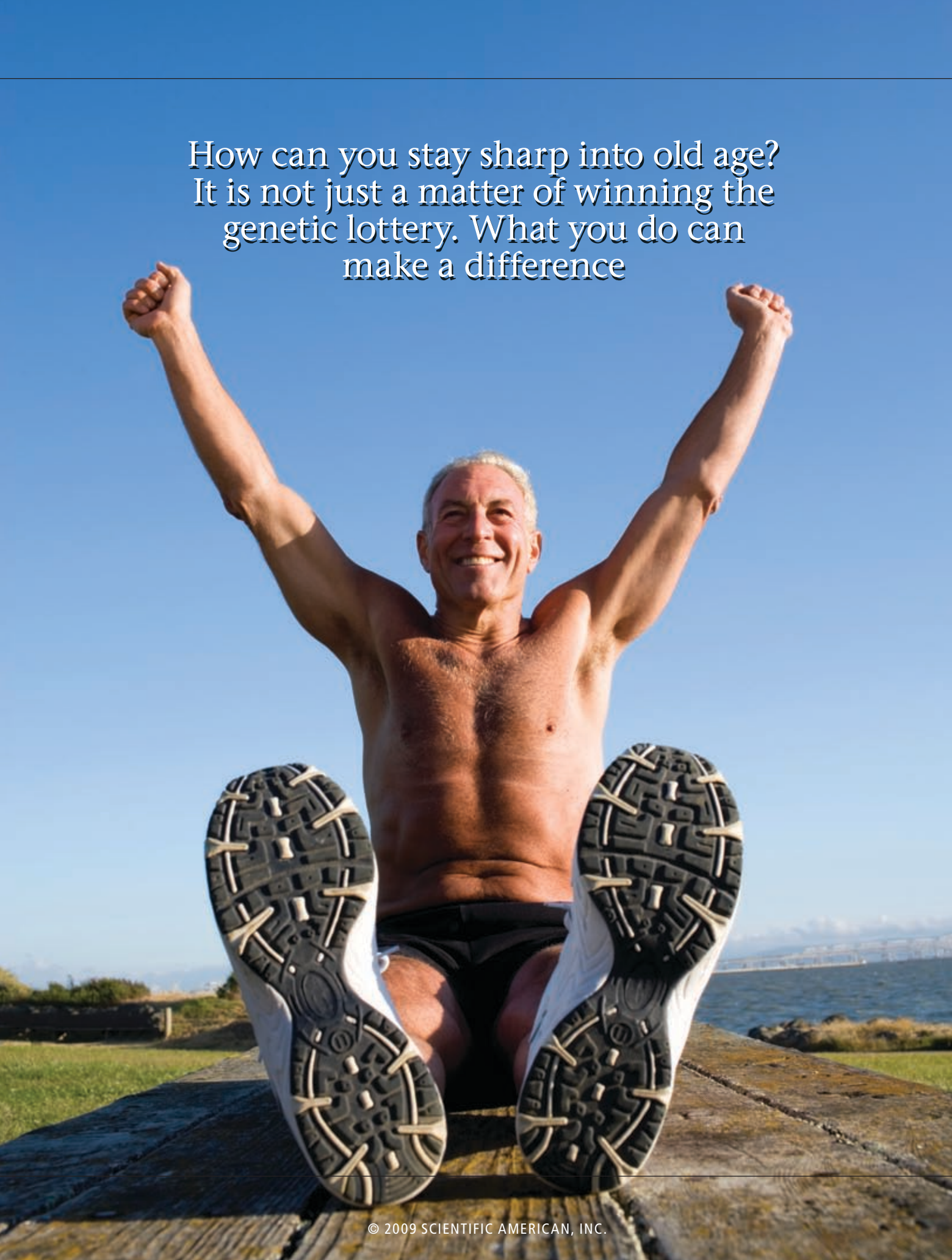
Fit Body, Fit Mind?

As everybody knows, if you do not work out, your muscles get flaccid. What most people don't realize, however, is that your brain also stays in better shape when you exercise. And not just challenging your noggin by, for example, learning a new language, doing difficult crosswords or taking on other intellectually stimulating tasks. As researchers are finding, *physical* exercise is critical to vigorous mental health, too.

By Christopher Hertzog, Arthur F. Kramer, Robert S. Wilson and Ulman Lindenberger

NOAH CLAYTON *Getty Images*

How can you stay sharp into old age? It is not just a matter of winning the genetic lottery. What you do can make a difference



At one time, the accepted stereotype was that "old dogs can't learn new tricks." Science proved *this dictum must be discarded*.

Stimulating challenges such as puzzles help us keep our edge.

K-P WOLF *Getty Images*

Surprised? Although the idea of exercising cognitive machinery by performing mentally demanding activities—popularly termed the "use it or lose it" hypothesis—is better known, a review of dozens of studies shows that maintaining a mental edge requires more than that. Other things you do—including participating in activities that make you think, getting regular exercise, staying socially engaged and even having a positive attitude—have a meaningful influence on how effective your cognitive functioning will be in old age.

Further, the older brain is more plastic than is commonly known. At one time, the accepted stereotype was that "old dogs can't learn new tricks." Science has proved that this dictum must be discarded. Although older adults generally learn new pursuits more slowly than younger people do and cannot reach the peaks of expertise in a given field that they might have achieved if they had started in their youth, they nonetheless can improve their cognitive performance through effort—forestalling some of the declines in cognition that come with advancing age. As John Adams, one of the founding fathers and the second U.S. president, put it: "Old minds are like old horses; you must exercise them if you wish to keep them in working order."

The news comes at a propitious time. The proportion of older adults in the U.S. and in other industrial nations continues to grow: in 1900, 4.1 percent of U.S. citizens were older than 65, but by

FAST FACTS

Aging and the Brain

1» **We are used to thinking of intelligence as largely a matter of genetic inheritance, but that is not the whole picture. What you do affects your mental well-being: staying physically and mentally active helps us stay sharp as we age.**

2» **Nevertheless, our personal efforts to bolster cognitive enhancement cannot forestall all declines in our cognitive performance.**

3» **What is especially surprising is the powerful link between physical activity and mental acuity. Staying fit helps us keep cognition more robust as well.**

2000 that amount had jumped to 12.6 percent; by 2030, 20 percent of us will be in that category. From a societal point of view, prolonging independent functioning is both a desirable goal in itself and a way of deferring costs of long-term care. For individuals, maintaining optimal cognitive functioning is worthwhile simply because it promises to enhance quality of life through the years.

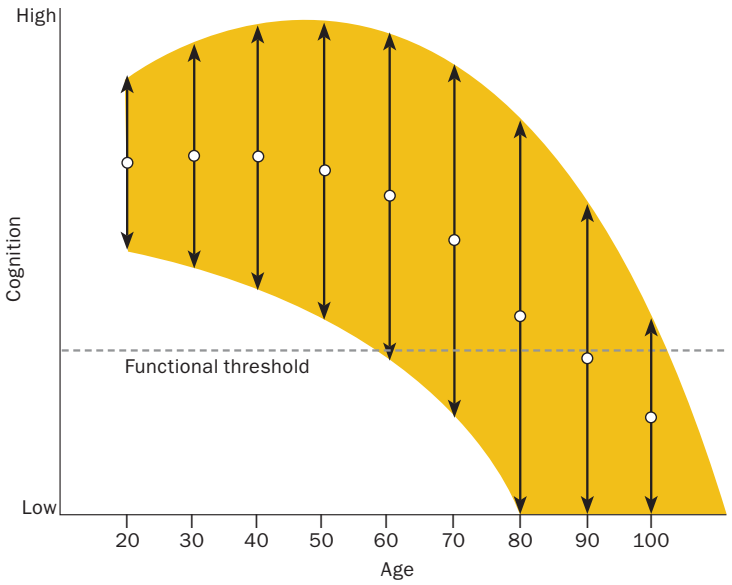
Mental Training

How to keep minds keen over an entire life span is a question philosophers have mulled since the earliest writings on record. As Roman orator Cicero put it: "It is exercise alone that supports the spirits, and keeps the mind in vigor." Modern research in this field began in the 1970s and 1980s, with studies that demonstrated that healthy older adults can improve performance to a greater extent than had been previously assumed. The earlier research did not fully address certain questions, such as how long adults could retain the new skills they had acquired through training, whether those specifically developed skills would also positively influence other areas of cognition needed in everyday life, and whether the studies done with small numbers of subjects would be broadly applicable to most members of society.

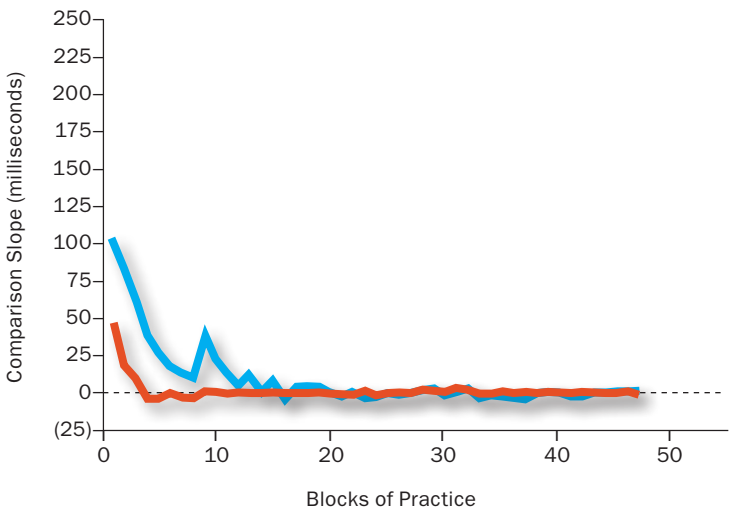
The latest experiments confirm that cognitive training does show substantial benefits for older adults and that these effects can be relatively long-lasting. Around the turn of this past century the federal government's National Institute on Aging funded a consortium of researchers to conduct a large-scale training study in a sample of older Americans. In 2002 psychologist Karlene Ball of the University of Alabama at Birmingham and her colleagues published initial results on more than 2,500 individuals older than 65 who had received about 10 sessions of cognitive training. Participants were randomly assigned either to a cognitive-process training group to learn how to excel in one of three areas—memory, reasoning or visual search—or to a control group of subjects who did not receive training. At a follow-up two years later, the team randomly selected a set of the initial participants to get booster training prior to evaluation. The results showed strong training-effect sizes in each group as compared with controls, along with a pattern of specificity in performance improvements. For example, individuals trained in visual search evinced strong gains in visual search performance but little improvement, relative to controls, on the memory and reasoning tests, a typical finding in training research. Data from retests five years later on the

Capabilities over Time

An individual's cognitive function can vary from maturity into old age. Although good habits can promote sound thinking within a given range (*top graph*), we cannot completely halt the effects of aging (*bottom graph*).



Cognitive function can change over a lifetime (*shaded area*). In addition to physical factors, environmental influences—such as engaging in mentally stimulating activities and exercising—can cause performance to boost or dip.



Older adults (mean age 72, *blue*) were slower than younger adults (mean age 21, *red*) to search memory (comparison slope, *vertical axis*) to verify whether a word was one of a set they had committed to memory a short time earlier. But with enough practice, they could speedily identify target words without needing to search for them, producing zero slopes.

SCIENTIFIC AMERICAN MIND; SOURCE FOR TOP GRAPH: "ENRICHMENT EFFECTS ON ADULT COGNITIVE DEVELOPMENT: CAN THE FUNCTIONAL CAPACITY OF OLDER ADULTS BE PRESERVED AND ENHANCED?" BY C. HERZOG ET AL., IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST* (SUPPLEMENT TO *PSYCHOLOGICAL SCIENCE*), ASSOCIATION FOR PSYCHOLOGICAL SCIENCE (IN PRESS); SOURCE FOR BOTTOM GRAPH: "AGING AND INDIVIDUAL DIFFERENCES IN THE DEVELOPMENT OF SKILLED MEMORY SEARCH PERFORMANCE," BY C. HERTZOG ET AL., IN *PSYCHOLOGY AND AGING*, VOL. 11, NO. 3; 1996

sample found that measurable training benefits were still present after the longer interval.

More impressive, however, are recent training studies that focus on what psychologists call executive function—how a person plans a strategic approach to a task, controls what is attended to, and how he or she manages the mind in the process. Unlike training that focuses on very specific skills, such as memorization strategies, training that aims to help people to control how they think appears to work on broader skills that are helpful in many situations that require thinking. For instance, psychologist Chandramallika Basak and her colleagues at the University of Illinois recently showed that training in a real-time strategy video game that demands planning and executive control not only improved game performance but enhanced performance on other tasks measuring aspects of executive control. Other results suggest that psychologists are learning how to train higher-level skills that may have a broader effect on cognitive function.

You don't have to have specialized training, however, to achieve cognitive gains or ward off cognitive decline. Everyday activities such as reading can help. We reviewed evidence on activity-related cognitive enrichment in more than a dozen studies. In 2003 neuropsychologist Robert S. Wilson and his colleagues at Rush University Medical Center in Chicago recruited more than 4,000 elderly people from a geographically defined community and rated their frequency of participation in seven cognitive activities (for instance, reading magazines). At three-year intervals for a mean of nearly six years, participants completed an in-home interview that included brief tests of cognitive function. More frequent cognitive activity at the outset was associated with reduced rate of cognitive decline over time.

Getting Physical

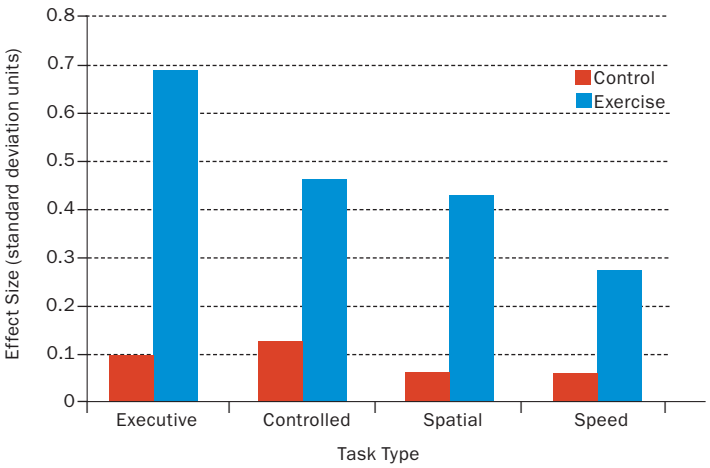
Over the past decade several studies have underscored the link between physical activity and cognition. For instance, in a study published in 2001 neuropsychiatrist Kristine Yaffe of the University of California, San Francisco, and her colleagues recruited 5,925 women older than 65 at four different medical centers across the U.S. The participants were all free of any physical disability that would limit their ability to walk or pursue other physical activities. The volunteers were also screened to ensure that they did not have a cognitive impairment. The researchers then assessed their physical activity by asking the women how many city blocks they walked and how many flights of stairs they climbed daily and gave them a questionnaire to fill out about their levels of participation in 33 different physical activities. After six to eight years, the researchers assessed the women's level of cognitive function. The most active women had a 30 percent lower risk of cognitive decline. Interestingly, walking distance was related to cognition, but walking speed was not. It seems that even moderate levels of physical activity can serve to limit declines in cognition in older adults.

Moderate movement is good, but toning your circulatory system with aerobic exercise may be the real key to brain fitness. In a 1995 study of 1,192 healthy 70- to 79-year-olds, cognitive neuroscientist Marilyn Albert of Johns Hopkins University

After six to eight years, they assessed the women's level of cognitive function. The most active had a *30 percent lower risk of decline*.

The *Power* of Pumping Iron

Older adults who participated in aerobic exercise (walking) outperformed those in programs for stretching and toning (controls) in cognitive task areas: executive (related to planning and multitasking), controlled (effortful processes in response to novel situations), spatial (dealing with spatial information in perception or memory) and speed.



SOURCE: "FITNESS EFFECTS ON THE COGNITIVE FUNCTION OF OLDER ADULTS: A META-ANALYTIC STUDY," BY STANLEY J. COLCOMBE AND ARTHUR F. KRAMER, IN *PSYCHOLOGICAL SCIENCE*, VOL. 14, NO. 2; MARCH 2003

CIRCLESTOCK *Corbis*

Physical activity bolsters memory and thwarts dementia.

and her colleagues measured cognition with a battery of tasks that took approximately 30 minutes to complete and included tests of language, verbal memory, nonverbal memory, conceptualization and visuospatial ability. They found that the best predictors of cognitive change over a two-year period included strenuous activity and peak pulmonary expiratory flow rate. In an investigation published in 2004 epidemiologist Jennifer Weuve of Harvard University and her colleagues also examined the relation between physical activity and cognitive change over a two-year period in 16,466 nurses older than 70. Participants logged how much time they spent per week in a variety of physical activities (running, jogging, walking, hiking, racket sports, swimming, bicycling, aerobic dance) over the past year and provided self-reports of walking pace in minutes per mile. Weuve's group observed a significant relation between energy expended in physical activities and cognition, across a large set of cognitive measures.

The research that we have described thus far has examined mental performance over relatively short periods—just several years. A few studies have begun to look at what happens over longer timescales. In 2003 psychiatrist Marcus Richards of University College London and his colleagues examined in a cohort of 1,919 men and women the influence of self-reported physical exercise and leisure-time activities at age 36 on memory at age 43 and on memory change from ages 43 to 53. Analyses indicated that engagement in physical exercise and other leisure-time activities at 36 was associated with higher memory scores at 43. Physical activity at 36 was also associated with a slower rate of memory decline from 43 to 53 years of age after adjusting for spare-time activity and other variables. The data also suggested little memory protection for those who stopped exercising after 36 but protection for those individuals who began to exercise after this time.

In 2005 then graduate student Suvi Rovio of the Karolinska Institute in Sweden and her colleagues examined the relation between physical activity at middle age and risk of dementia an average of 21

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Socializing—and even a positive attitude—helps your brain stay healthier.

years later, when the cohort was between 65 and 79 years of age. Subjects indicated how often they participated in leisure-time physical activities that lasted at least 20 to 30 minutes and caused breathlessness and sweating. Conducting such activity at midlife at least twice a week was associated with a reduced risk of dementia in later life. Indeed, participants in the more active group had 52 percent lower odds of having dementia than the more sedentary group did.

Mind-Body Connection

It makes sense that training or participation in mentally stimulating activities would help cognition, but it is perhaps less immediately obvious why physical activity would have such an effect. Consider the increasingly well-documented link between physical activity and disease. A plethora of studies have examined the health benefits of exercise and a nonsedentary lifestyle for prevention of disease. For example, we now know that physical activity reduces the risk of cardiovascular-related death, type 2 diabetes, colon and breast cancer, and osteoporosis. On the other hand, cardiovascular disease, diabetes and cancer have been associated with compromised cognition. Therefore, you might expect that increased physical activity and exercise would maintain cognition by reducing risk of diseases associated with cognitive decline.

In a study published in 2006 psychologist Stanley J. Colcombe of the University of Illinois and his colleagues examined the influence of fitness training on potential changes in brain structure. The six-month trial included 59 healthy but sedentary community-dwelling volunteers, age 60 to 79. Brain scans after fitness training showed that even relatively short exercise interventions can begin to restore some of the losses in brain volume associated with normal aging.

Supporting these findings, a large body of nonhuman animal research has demonstrated a number of changes in brain structure and function after animals are exposed to enriched, or complex, environments. Enriched environments usually include running wheels, a multitude of toys and objects to climb that are changed frequently, and animal companions. Exposure to such environments yields several physiological benefits. First, it increases the formation of new dendrite branches and synapses—the areas of neural cells that receive and send communication signals. It also increases the number of glial cells, which support the health of neurons, and expands the brain's oxygen-supplying capillary network. Enriched environments foster the development of new neurons and create a cascade of molecular and neurochemical changes, such as an increase in neurotrophins—molecules that protect and grow the brain.

Doing puzzles and push-ups are helpful for some—but other factors also boost mental fitness. For one, getting involved in social groups both improves cognition in general and seems to help thwart the arrival of dementia. The traditional focus of this research has been on relatively objective measures of social isolation versus connectedness, including the extent to which a person participates in activities that prominently involve social interaction (such as doing volunteer work), the number of friends and relatives an individual contacts regularly (in other words, the size of his or her social network), and marital status. Findings about the positive aspects of attitudes and beliefs on adult

More Science
See the *Psychological Science in the Public Interest* article, "Enrichment Effects on Adult Cognitive Development: Can the Functional Capacity of Older Adults Be Preserved and Enhanced?" on which this story is based, at the Association for Psychological Science's Web site: **www.psychologicalscience.org**

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cognition are spottier. In large part, positive beliefs and attitudes may have important indirect effects on cognitive enrichment because of their influence on the kinds of behaviors (for instance, exercise and mentally stimulating activities) that are known to be associated with cognitive enrichment.

More generally, individuals who are optimistic, agreeable, open to new experiences, conscientious, positively motivated and goal-directed are more likely to undergo successful aging, to take advantage of opportunities, to cope more effectively with life circumstances, to effectively regulate emotional reactions to events, and to maintain a sense of well-being and life satisfaction in the face of challenge.

Positive attitudes may have important effects on cognitive enrichment because of their influence on healthy behaviors.

And just as maintaining some activity patterns in old age may reduce risk of cognitive decline, the persistence of other patterns of behavior may actually increase the risk. Chronic psychological distress—resulting from depression, anxiety and negative emotions such as anger and shame—is associated with a variety of negative outcomes in adulthood, including cognitive decline. The tendency to experience psychological distress is often called neuroticism. Studies have consistently found a higher level of neuroticism to be linked to an increased incidence of Alzheimer's disease and mild cognitive impairment in old age.

Enriching Cognition

Clearly, there is no magic pill or one-shot vaccine that inoculates the individual against cognitive decline in old age. Thus, public policy regarding cognitive enrichment should follow a health prevention model. Policy leaders might promote intellectual activities that are inherently meaningful for older adults, perhaps as embedded in larger social contexts (for example, the Elderhostel movement or adult continuing education). A critical issue for future research will be to understand how an engaged way of life can be promoted and implemented in midlife, during the working years. Given inevitable conflicts between work demands and time available for other roles (parenting, for one) and activities, it would be useful to know whether work-related activity programs (such as availability and use of physical exercise facilities at or near the workplace) could help foster an enriching lifestyle.

At the same time, the public must be aware that there is still much that is not known about cognitive fitness in old age, as well as some controversy about the magnitude and durability of mental exercise outcomes. People are beginning to market computer games and other means of exercising the mind, often making strong claims about the effectiveness of expensive products that have not been backed by actual scientific studies. Consumers should look for evidence demonstrating the benefits of any such products, which may not necessarily incorporate all the features needed to enhance mental fitness in old age.

The next decades offer much promise for expanding our knowledge about aging and cognition. We may soon discover whether the limits on successful cognitive functioning in old age that were once seen as insurmountable can ultimately be viewed as pessimistic assumptions that focused on observable age-related decline rather than the potential for maximizing human performance through cognitive enrichment. Just as advances in medical science may lead to increased longevity through vehicles such as effective treatments for dementia-causing illnesses, advances in psychological science can make important contributions to improving the quality of life of long-living older adults, in part by empirically demonstrating that attitudes and behaviors can promote cognitive functioning in old age and, more generally, by showing how behavioral interventions can help us all age successfully. M

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New research explains music's power over human emotions and its benefits to our mental and physical well-being

Why Music

By Karen Schrock

As a recreational vocalist, I have spent some of the most moving moments of my life engaged in song. As a college student, my eyes would often well up with tears during my twice-a-week choir rehearsals. I would feel relaxed and at peace yet excited and joyful, and I occasionally experienced a thrill so powerful that it sent shivers down my spine. I also felt connected with fellow musicians in a way I did not with friends who did not sing with me.

I have often wondered what it is about music that elicits such emotions. Philosophers and biologists have asked the question for centuries, noting that humans are universally drawn to music. It consoles us when we are sad, pumps us up in happier times and bonds us to others, even though listening to an iPod or singing "Happy Birthday" does not seem necessary for survival or reproduction.

Some scientists conclude that music's influence may be a chance event, arising from its ability to hijack brain systems built for other purposes such as language, emotion and movement. As Harvard University psychologist Steven Pinker famously put it in his 1997 book *How the Mind Works* (W. W. Norton), music is "auditory cheesecake," a confection crafted to tickle the areas of the mind that evolved for more important functions. But as a result of that serendipity, music seems to offer a novel system of communication rooted in emotions rather than in meaning. Recent data show, for example, that music reliably conveys certain sentiments: what we feel when we hear a piece of music is remarkably similar to what everybody else in the room is experiencing.

Emerging evidence also indicates that music brings out predictable responses across cultures and among people of widely varying musical or cognitive abilities. Even newborn infants and people who cannot discern pitch enjoy music's emotional effect. "Certainly music seems to be the most direct form of emotional communication," opines renowned neurologist Oliver Sacks of

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Moves Us

Columbia University, author of the recent book *Musicophilia* (Knopf, 2007). "It really seems to be as important a part of human life and communication as language and gesture."

Such dialogue provides a way for people to connect emotionally and thus may reinforce the ties that underlie the formation of human societies, which have clear survival advantages. Musical rhythms may have even facilitated certain physical interactions such as marching or dancing together, further cementing our social ties. In addition, tunes may work to our benefit on an individual level, manipulating mood and even human physiology more effectively than words can—to excite, energize, calm or promote physical fitness. All these benefits are causing people to reconsider whether music is truly as frivolous as it seems.

Mosaic in the Mind

Throughout recorded history, people have attempted to explain music's sway over the human spirit. Music has been labeled everything from a gift of the heavens to a tool of the Devil, from an extension of mathematics to a side effect of language processing. Charles Darwin was famously stumped by music's ubiquitous presence around the world: man's predilection for music, he wrote in 1871 in *The Descent of Man,* "must be ranked among the most mysterious with which he is endowed."

Since the 1950s many psychologists have attempted to explain music's power by comparing music appreciation with speech. After all, an understanding of both music and speech requires, at its most primitive level, the ability to detect sounds. The brain's auditory cortex, an area dedicated to hearing, is now known to process basic musical elements such as pitch (a note's frequency) and volume; the neighboring secondary auditory areas digest more complex musical patterns such as harmony and rhythm. [For more on how the brain processes music, see "Music in Your Head," by Eckart O. Altenmüller; SCIENTIFIC AMERICAN MIND, January 2004.]

In addition, language and music both contain a grammar that organizes smaller components such as words and musical chords, phrases made up of melody or prosody (the melodic line

People in every culture enjoy making music in groups. They sing hymns in church, play instruments in bands and belt out "Happy Birthday" at parties. Music may confer social cohesiveness by forging emotional ties among individuals.

of speech), and tension and resolution. Indeed, music has been found to excite brain regions involved in understanding and producing language, including Broca's area and Wernicke's area, both located in the left hemisphere on the surface of the brain. (The majority of people process language mainly in the brain's left hemisphere but encode most aspects of music in the analogous regions on the right.) Thus, musical syntax—for instance, the order of chords in a phrase—could have arisen from the mechanisms that evolved to organize and understand grammar.

But tunes also recruit other brain systems, principally perhaps those governing emotions such as fear, joy and sorrow. For example, damage to the amygdala, the brain's fear hub, impairs a person's ability to feel scared and, in some studies, sad in response to song. Many modern researchers thus conjecture that music evolved by piggybacking on a unique constellation of brain regions dedicated to language, feelings and other functions. "I think there's a very good chance that music is simply a side effect of things that evolved for other reasons," says auditory scientist Josh McDermott, now at New York University.

FAST FACTS

Musical Minds

1» Some scientists conclude that music's influence over us may be a chance event, arising from its ability to hijack brain systems built for other purposes such as language, emotion and movement.

2» Music seems to offer a novel method of communication rooted in emotions rather than in meaning. Research shows that what we feel when we hear a piece of music is remarkably similar to what everybody else in the room is experiencing.

3» Songs facilitate emotional bonding and even physical interactions such as marching or dancing together and thus may help cement ties that underlie the formation of human societies. In addition, tunes may work to our benefit on an individual level, manipulating mood and even human physiology more effectively than words can.

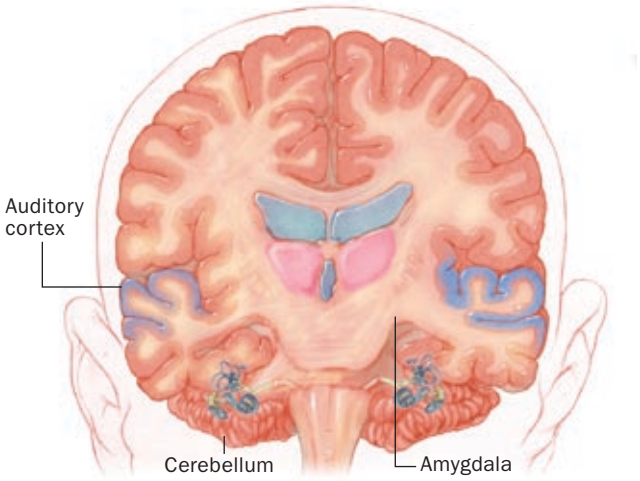
Universal Language

Music's simultaneous activation of diverse brain circuits seems to produce some remarkable effects. Instead of facilitating a largely semantic dialogue, as language does, melody seems to mediate an emotional one. When a composer writes a lamentation or a toddler exuberantly bangs out a rhythm on a pot, that person is not only revealing his or her own emotional state but also causing listeners to share those feelings. Several pieces of research indicate that music reliably conveys the intended emotion in all people who hear it. In the late 1990s neuroscientist Isabelle Peretz and her colleagues at the University of Montreal found that Western listeners universally agree on whether a song using Western tonal elements is happy, sad, scary or peaceful.

Music's emotional content may even be culturally transparent. This past April neuroscientist Tom Fritz of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, and his colleagues exposed members of the Mafa ethnic group in Cameroon who had never heard Western music to excerpts of classical piano music. The researchers found that the adults who listened to the excerpts consistently identified them as happy, sad or scary just as Western listeners would. Thus, the ability of a song to elicit a particular emotion does not necessarily depend on cultural background.

The musical tongue may also transcend more fundamental communication barriers. In studies conducted over the

BOB SACHA *Corbis (gospel choir)*; HULTON-DEUTSCH COLLECTION/CORBIS (*Durbar celebration*); FRÉDÉRIC SOLTAN *Sygma/Corbis (desert tribe in India)*; HANS NELEMAN *Getty Images (singing "Happy Birthday")*



Music activates diverse brain regions. These areas include the auditory cortex, which is devoted to hearing, movement centers such as the cerebellum, and the amygdala, an emotion hub.

ANDREW SWIFT (*brain diagram*)

past decade, cognitive psychologist Pam Heaton of Goldsmiths, University of London, and her research team played music for both autistic and nonautistic children, comparing those with similar language skills, and asked the kids to match the music to emotions. In the initial studies, the kids simply chose between happy and sad. In later studies, Heaton and her colleagues introduced a range of complex emotions, such as triumph, contentment and anger, and found that the kids' ability to recognize these feelings in music did not depend on their diagnosis. Autistic and typical children with similar verbal skills performed equally well, indicating that music can reliably convey feelings even in people whose ability to pick up emotion-laden social cues, such as facial expressions or tone of voice, is severely compromised.

Recently, in a clever experiment, acoustics scientist Roberto Bresin and his co-workers at the Royal Institute of Technology in Stockholm garnered quantitative support for the idea that music is a universal language. Instead of asking volunteers to make subjective judgments about a piece of music, scientists asked them to manipulate the song—in particular, its tempo, volume and phrasing—to maximize a given emotion. For a happy song, for instance, a participant was supposed to manipulate these variables by adjusting sliders so that the song sounded as cheerful as possible; then as sad as possible; then scary, peaceful and neutral.

The researchers found that the participants—expert musicians and, in another study, seven-year-old children—all landed on the same tempo for each song to bring out its intended emotion, be it happiness, sadness, fear or tranquility. These findings, which Bresin reported at the 2008 Neuromusic III conference in Montreal, bolster the idea that music contains information that elicits a specific emotional response in the brain regardless of personality, taste or training. As such, music may constitute a unique form of communication.

Choral Bonding

Music's ability to convey feelings may underlie one of its most important benefits. In most cultures, music is almost always a communal event: everyone gets together to sing, dance, and play instruments. Even in Western societies, which uniquely differentiate musical performers from listeners, people enjoy music together in a wide variety of settings: dancing at a wedding or a nightclub, singing hymns in church, crooning with their kids, Christmas caroling and singing "Happy Birthday" at a party. The popularity of such rituals suggests that music confers social cohesiveness, perhaps by creating empathetic connections among members of a group.

But empathy may not be the only means by which music facilitates unity. Studies show that when people listen to music, the motor regions of the brain are also active—probably for the purpose of processing rhythm. These include premotor areas, which prepare a person for action, and the cerebellum, which coordinates physical movement. Some research-

(The Author)

KAREN SCHROCK is an editor at *Scientific American Mind*.

Upbeat music primes body systems needed for high-energy movement. That effect may partly explain why many people enjoy listening to hip-hop or rock while exercising.

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ers have a hunch that part of music's power stems from its tendency to echo and synchronize our activities. "I can see how rhythm and physical action would have mutual resonance in the nervous system," speculates neuropsychologist Robert Zatorre of McGill University. "All sound is produced by movement. When you hear a sound, it's because something has moved."

Then it is a small step from walking, breathing, and hearing a heartbeat—natural rhythmic sounds that are not intrinsically musical—to purposely keeping time or matching another's gait. "Part of the reason music works is that when you hear a pattern, you can join in. You know how to organize your muscles to produce the sound you are hearing," Zatorre explains. In this way, the rhythm of a song could also serve as social glue by promoting a kind of physical bonding.

The idea that music may promote a type of nonverbal togetherness gains additional support from a 2008 study by neuroscientists Nikolaus Steinbeis of the Max Plank Institute for Human Cognitive and Brain Sciences and Stefan Koelsch of the University of Sussex in England. Steinbeis and Koelsch used functional magnetic resonance imaging to pinpoint a brain area that responded to chords but not to words, in a task in which volunteers listened to both. The responsive region turned out to be the superior temporal sulcus, a part of the brain's surface near the ears that responds to nonverbal social cues such as nonspeech vocal utterances, eye movements and body movements. The activation of this region hints that music may indeed be helping to forge social ties.

Whatever its origin, such cohesiveness is extremely valuable to a communal animal such as ourselves; traits that enhance such unity tend to persist. "Music is usually a social activity," Koelsch explains. "While people make music, they communicate and cooperate with one another. In a way, they practice social activity and social functions. This social behavior is highly important for the human species."

Music is a powerful tool for relaxing patients about to undergo surgery and ameliorating behavioral issues in children.

Musical Medicine

Music also bestows advantages on us as individuals. Underlying our conscious impressions of a tune are physiological effects that can improve our mental and physical well-being. Studies show that upbeat, tense or exciting music can physically excite the listener, triggering the body's fight-or-flight response: heart and breathing rates increase, a person may break out in a sweat, and adrenaline enters the bloodstream. This "pumping up" effect explains why so many people enjoy listening to rock or hip-hop while they work out—the music primes the physiological systems needed for high-energy movement. The psychological effect is important, too; music is a welcome distraction, making exercising more fun. Energizing melodies tend to boost mood in general, waking us up if we are feeling tired and creating a sense of excitement in any situation.

On the other hand, music can be calming, reducing the levels of the stress hormone cortisol in the blood, lowering heart and respiration rates, and alleviating pain, according to several studies. The classic example of this anxiety-reducing effect is a mother soothing her baby to sleep with a lullaby. In addition, clinical studies have shown music to be a powerful tool for relaxing patients about to undergo surgery, controlling their pain, and ameliorating behavioral issues in children and people with dementia.

In 2000 gerontology researcher and nurse Linda A. Gerd-

ner of the University of Arkansas for Medical Sciences exposed 39 severely impaired Alzheimer's patients to music they liked twice a week for six weeks. The favored music, as determined by a questionnaire, reduced the patients' agitation levels during and after the listening period much more than did a similar schedule of classical "relaxation" music they heard at a separate time. Beloved music also has been found to reduce pain during surgery and child labor. The analgesic effect apparently outlasts the listening: exposure to music during labor or a medical procedure can lessen the soreness experienced afterward, even after the music has stopped.

And of course people self-medicate with music all the time. Broad surveys have found that nearly everybody reports listening to music by themselves for the purpose of enhancing or altering their emotional state.

Built for Song?

Given its undisputed allure, might music have some unique roots in the brain in addition to piggybacking on other systems? Researchers have described several cases of brain damage that impaired a person's capacity to feel emotions inspired by music but not by other stimuli. Lawrence Freedman, a friend of Sacks's, selectively lost his passion for classical music after a concussion from a bike accident. Freedman could still recognize the classical works he used to love, Sacks says, and he was still moved by visual art and other experiences, but music gave him no pleasure. Presumably the accident damaged a part of the brain dedicated specifically to enthusiasm for music, although no one knows exactly what part of the brain that is.

Other researchers argue that music has independent origins because the capacity to appreciate it appears to be hardwired at birth. Various studies show that infants pay rapt attention to song and even seem to prefer song to speech. In preliminary findings published in July 2008 in *Nature Precedings,* neuroscientists Maria Cristina Saccuman and Daniela Perani of Vita-Salute San Raffaele University in Italy and their colleagues showed that music activates regions in newborns' brains similar to those activated in more mature listeners. Saccuman and Perani used fMRI to see how the brains of one- to three-day-old newborns responded to classical music and found a pattern that mirrored music processing in adults: the infants' right hemisphere auditory system responded more strongly than the left. The researchers also altered the music by either making a section in the middle of the excerpt suddenly jump into another key or playing the entire musical segment in clashing keys. These more jarring passages preferentially activated the infants' left inferior frontal cortex, an area implicated in musical syntax processing in adults, and the limbic system, the seat of emotional response, just as happens in adults. "The brain seems to be born ready to process music," Saccuman concludes.

This innate readiness for music is thought to be tied to the phenomenon of motherese, the peculiar singsong way people

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Motherese—the singsong way adults instinctually talk to babies—may tap into infants' innate ability to respond to music.

instinctually talk to babies. The universal use of motherese has led some experts to speculate that it may be the original starting point for both music and language. Some experts, notably cognitive archaeologist Steven Mithen of the University of Reading in England, theorize that language and music both evolved from a musical protolanguage that our hominid ancestors used. Neandertals and other extinct hominids appear to have vocal chord structures that suggest they could sing, according to Mithen. Ancient humans certainly played instruments: researchers have uncovered bone flutes that are tens of thousands of years old.

The truth is that we may never know why music exists; evolutionary theories are very difficult to test. But even amid uncertainty about music's origins, we can still use songs to pump ourselves up or calm ourselves down, ease pain and anxiety, bond with others or simply move people to tears. "Music is the most direct and mysterious way of conveying and evoking feeling," Sacks professes. "It is a way of connecting one consciousness to another. I think the nearest thing to telepathy is making music together." M

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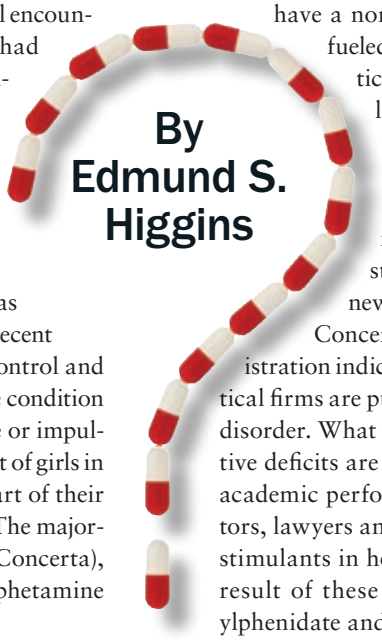
Do ADHD Drugs Take a Toll on the Brain?

Research hints that hidden risks might accompany long-term use of the medicines that treat attention-deficit hyperactivity disorder

A few years ago a single mother who had recently moved to town came to my office asking me to prescribe the stimulant drug Adderall for her sixth-grade son. The boy had been taking the medication for several years, and his mother had liked its effects: it made homework time easier and improved her son's grades.

At the time of this visit, the boy was off the medication, and I conducted a series of cognitive and behavioral tests on him. He performed wonderfully. I also noticed that off the medication he was friendly and playful. On a previous casual encounter, when the boy had been on Adderall, he had seemed reserved and quiet. His mother acknowledged this was a side effect of the Adderall. I told her that I did not think her son had attention-deficit hyperactivity disorder (ADHD) and that he did not need medication. That was the last time I saw her.



By Edmund S. Higgins

Attention-deficit hyperactivity disorder afflicts about 5 percent of U.S. children—twice as many boys as girls—age six to 17, according to a recent survey conducted by the Centers for Disease Control and Prevention. As its name implies, people with the condition have trouble focusing and often are hyperactive or impulsive. An estimated 9 percent of boys and 4 percent of girls in the U.S. are taking stimulant medications as part of their therapy for ADHD, the CDC reported in 2005. The majority of patients take methylphenidate (Ritalin, Concerta), whereas most of the rest are prescribed an amphetamine such as Adderall.

Although it sounds counterintuitive to give stimulants to a person who is hyperactive, these drugs are thought to boost activity in the parts of the brain responsible for attention and self-control. Indeed, the pills can improve attention, concentration and productivity and also suppress impulsive behavior, producing significant improvements in some people's lives. Severe inattention and impulsivity put individuals at risk for substance abuse, unemployment, crime and car accidents. Thus, appropriate medication might keep a person out of prison, away from addictive drugs or in a job.

Over the past 15 years, however, doctors have been pinning the ADHD label on—and prescribing stimulants for—a rapidly rising number of patients, including those with moderate to mild inattention, some of whom, like the sixth grader I saw, have a normal ability to focus. This trend may be fueled in part by a relaxation of official diagnostic criteria for the disorder, combined with a lower tolerance in society for mild behavioral or cognitive problems.

In addition, patients are no longer just taking the medicines for a few years during grade school but are encouraged to stay on them into adulthood. In 2008 two new stimulants—Vyvanse (amphetamine) and Concerta—received U.S. Food and Drug Administration indications for treating adults, and pharmaceutical firms are pushing awareness of the adult forms of the disorder. What is more, many people who have no cognitive deficits are opting to take these drugs to boost their academic performance. A number of my patients—doctors, lawyers and other professionals—have asked me for stimulants in hopes of boosting their productivity. As a result of these developments, prescriptions for methylphenidate and amphetamine rose by almost 12 percent a year between 2000 and 2005, according to a 2007 study.

With the expanded and extended use of stimulants comes mounting concern that the drugs might take a toll on the brain over the long run. Indeed, a smattering of recent studies, most of them involving animals, hint that stimulants could alter the structure and function of the brain in ways that may depress mood, boost anxiety and, contrary to their short-term effects, lead to cognitive deficits. Human studies already indicate the medications can adversely affect areas of the brain that govern growth in children, and some researchers worry that additional harms have yet to be unearthed.

TATIANA POPOVA iStockphoto (capsules on this page and on pages 41 and 42)

Medicine for the Mind

To appreciate why stimulants could have negative effects over time, it helps to first understand what they do in the brain. One hallmark of ADHD is an underactive frontal cortex, a brain region that lies just behind the forehead and controls such "executive" functions as decision making, predicting future events, and suppressing emotions and urges. This area may, in some cases, be smaller than average in ADHD patients, compromising their executive abilities. Frontal cortex function depends greatly on a signaling chemical, or neurotransmitter, called dopamine, which is released in this structure by neurons that originate in deeper brain structures. Less dopamine in the prefrontal cortex is linked, for example, with cognitive difficulty in old age. Another set of dopamine-releasing neurons extends to the nucleus accumbens, a critical mediator of motivation, pleasure and reward whose function may also be impaired in ADHD [*see illustration at right*].

Stimulants enhance communication in these dopamine-controlled brain circuits by binding to so-called dopamine transporters—the proteins on nerve endings that suck up excess dopamine—thereby deactivating them. As a result, dopamine accumulates outside the neurons, and the additional neurotransmitter is thought to improve the operation of neuronal circuits critical for motivation and impulse control.

Not only can methylphenidate and amphetamine ameliorate a mental deficit, they also can enhance cognitive performance. In studies dating back to the 1970s, researchers have shown that normal children who do not have ADHD also become more attentive—and often calmer—after taking stimulants. In fact, the drugs can lead to higher test scores in students of average and above-average intellectual ability [see "Smarter on Drugs," by Michael S. Gazzaniga; Scientific American Mind, Vol. 16, No. 3, 2005].

Since the 1950s, when doctors first started prescribing stimulants to treat behavior problems, millions of people have taken them without obvious incident. A number of studies have even exonerated them from causing possible adverse effects. For example, researchers have failed to find differences between stimulant-treated children and those not on meds in the larger-scale growth of the brain. In January 2009 child psychiatrist Philip Shaw of the National Institute of Mental Health and his colleagues used MRI scans to measure the change in the thickness of the cerebral cortex (the outer covering of the brain) of 43 youths between the ages of 12 and 16 who had ADHD. The researchers found no evidence that stimulants slowed cortical growth. In fact, only the unmedicated adolescents showed more thinning of the cerebrum than was typical for their age, hinting that the drugs might facilitate normal cortical development in kids with ADHD.

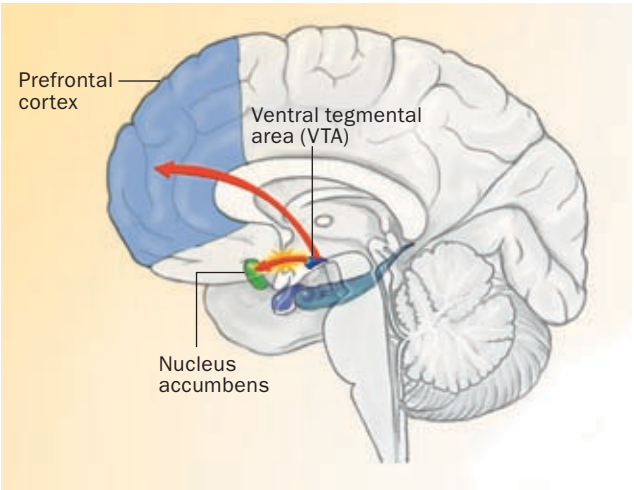
Altering Mood

Despite such positive reports, traces of a sinister side to stimulants have also surfaced. In February 2007 the FDA issued warnings about side effects such as growth stunting and psychosis, among other mental disorders. Indeed, the vast majority of adults with ADHD experience at least one additional psychiatric illness—often an anxiety disorder or drug addiction—in their lifetime. Having ADHD is itself a risk factor for other mental health problems, but the possibility also exists that stimulant treatment during childhood might contribute to these high rates of accompanying diagnoses.

After all, stimulants activate the brain's reward pathways, which are part of the neural circuitry that controls mood under normal conditions. And at least three studies using animals

Stimulating the Brain

Drug treatments for attention-deficit hyperactivity disorder enhance communication in brain circuits governed by the signaling molecule dopamine (*red arrows*).



TERESE WINSLOW

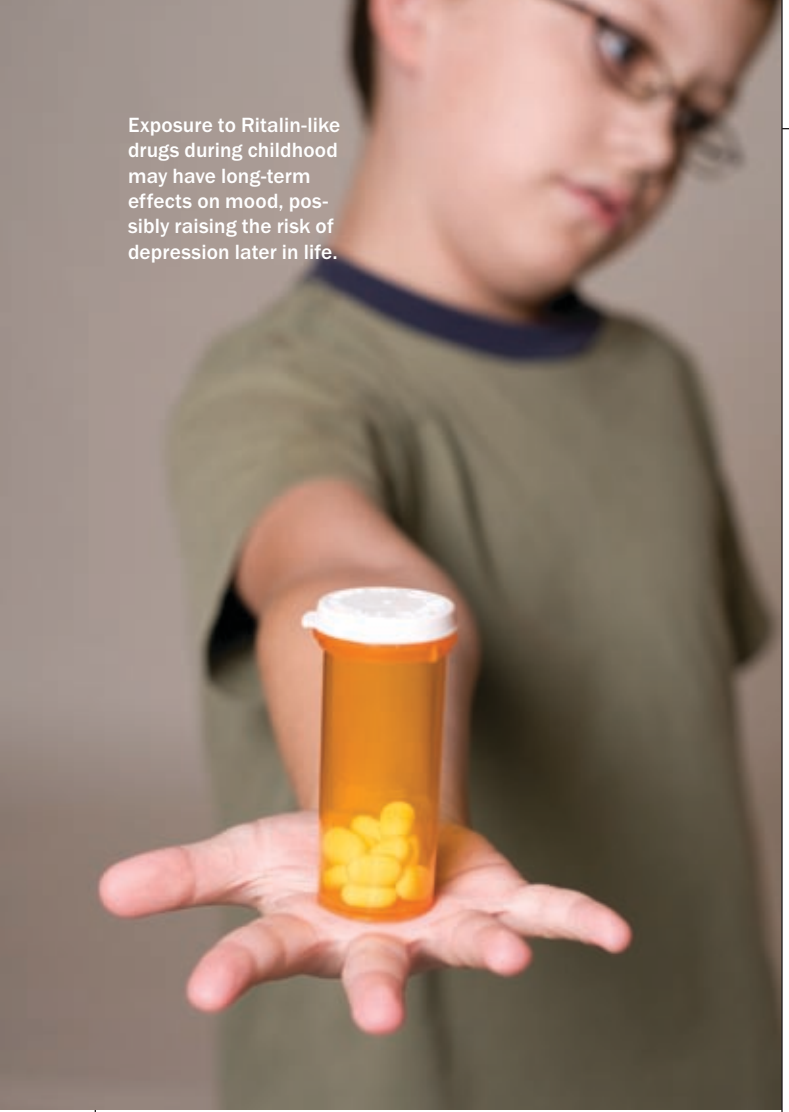
FAST FACTS

Drug Dilemma

1» Stimulant treatments for ADHD are effective; they can improve attention, concentration and productivity and suppress impulsive behavior, producing significant improvements in some people's lives.

2» Over the past 15 years doctors have been prescribing stimulants for a rapidly rising number of patients, who also increasingly take the drugs for many years. With the expanded and extended use of stimulants comes mounting concern that the drugs might wreak silent havoc on the brain over the long run.

3» A smattering of recent studies, most of them involving animals, hint that stimulants could alter the structure and function of the brain in ways that may depress mood, boost anxiety and, in sharp contrast to their short-term effects, lead to cognitive deficits.



Exposure to Ritalin-like drugs during childhood may have long-term effects on mood, possibly raising the risk of depression later in life.

GETTY IMAGES (*boy holding pills*)

hint that exposure to methylphenidate during childhood may alter mood in the long run, perhaps raising the risk of depression and anxiety in adulthood.

In an experiment published in 2003 psychiatrist Eric Nestler of the University of Texas Southwestern Medical Center and his colleagues injected juvenile rats twice a day with a low dose of methylphenidate similar to that prescribed for children with ADHD. When the rats became adults, the scientists observed the rodents' responses to various emotional stimuli. The rodents that had received methylphenidate were significantly less responsive to natural rewards such as sugar, sex, and fun, novel environments than were untreated rats, suggesting that the drug-exposed animals find such stimuli less pleasurable. In addition, the stimulants apparently made the rats more sensitive to stressful situations such as being forced to swim inside a large tube. Similarly, in the same year psychiatrist William Carlezon of Harvard Medical School and his colleagues reported that methylphenidate-treated preadolescent rats displayed a muted response to a cocaine reward as adults as well as unusual apathy in a forced-swim test, a sign of depression.

In 2008 psychopharmacologist Leandro F. Vendruscolo and his co-workers at Federal University of Santa Catarina in Brazil echoed these results using spontaneously hypertensive rats, which—like children with ADHD—sometimes show attention deficits, hyperactivity and motor impulsiveness. The researchers injected these young rats with methylphenidate for 16 days at doses approximating those used to treat ADHD in young people. Four weeks later, when the rats were young adults, those that had been exposed to methylphenidate were unusually anxious: they avoided traversing the central area of an open, novel space more so than did rats not exposed to methylphenidate. Adverse effects of this stimulant, the authors speculate, could contribute to the high rates of anxiety disorders among ADHD patients.

Adverse effects of the stimulant methylphenidate, some scientists speculate, could contribute to the high rates of anxiety among ADHD patients.

Copying Cocaine?

The long-term use of any drug that affects the brain's reward circuitry also raises the specter of addiction. Methylphenidate has a chemical structure similar to that of cocaine and acts on the brain in a very similar way. Both cocaine and methamphetamine (also called "speed" or "meth")—another highly addictive stimulant—block dopamine transporters just as ADHD drugs do [see "New Weapons against Cocaine Addiction," by Peter Sergo; Scientific American Mind, April/May 2008]. In the case of the illicit drugs, the dopamine surge is so sudden that in addition to making a person unusually energetic and alert, it produces a "high."

Recent experiments in animals have sounded the alarm that methylphenidate may alter the brain in ways similar to that of more powerfully addictive stimulants such as cocaine. In February 2009 neuroscientists Yong Kim and Paul Greengard, along with their colleagues at the Rockefeller University, reported cocainelike structural and chemical alterations in the brains of mice given methylphenidate. The researchers injected the mice with either methylphenidate or cocaine daily for two weeks. Both treatments increased the density of tiny extensions called spines at the ends of neurons bearing dopamine receptors in the rodent nucleus accumbens. Compared with cocaine, methylphenidate had a somewhat more localized influence; it also had more power over longer spines and less effect on short-

(The Author)

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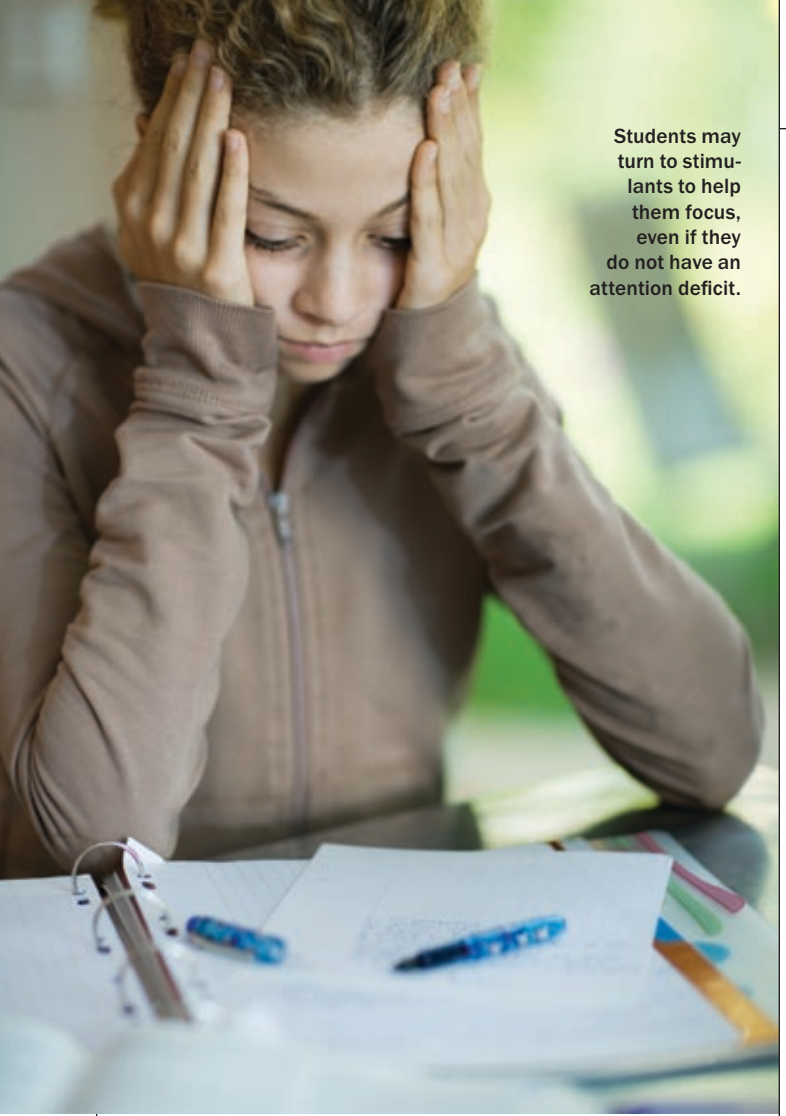


Students may turn to stimulants to help them focus, even if they do not have an attention deficit.

er ones. Otherwise, the drugs' effects were strikingly similar.

Furthermore, the scientists found that methylphenidate boosted the amount of a protein called ΔFosB, which turns genes on and off, even more than cocaine did. That result could be a chemical warning of future problems: excess ΔFosB heightens an animal's sensitivity to the rewarding effects of cocaine and makes the animal more likely to ingest the drug. Many former cocaine addicts struggle with depression, anxiety and cognitive problems. Researchers have found that cocaine has remodeled the brains of such ex-users. Similar problems—principally, perhaps, difficulty experiencing joy and excitement in life—could occur after many years of Ritalin or Adderall use.

Monkeys given amphetamine displayed lasting deficits in working memory, the short-term buffer that allows us to hold several things in mind.

Amphetamine and methylphenidate can also be addictive if abused by, say, crushing or snorting the pills. In a classic study published in 1995 research psychiatrist Nora Volkow, then at Stony Brook University, and her colleagues showed that injections of methylphenidate produced a cocainelike high in volunteers. More than seven million people in the U.S. have abused methylphenidate, and as many as 750,000 teenagers and young adults show signs of addiction, according to a 2006 report.

Typical oral doses of ADHD meds rarely produce such euphoria and are not usually addicting. Furthermore, the evidence to date, including two 2008 studies from the National Institute on Drug Abuse, indicates that children treated with stimulants early in life are not more likely than other children to become addicted to drugs as adults. In fact, the risk for severe cases of ADHD may run in the opposite direction. (A low addiction risk also jibes with Carlezon's earlier findings, which indicated that methylphenidate use in early life mutes adult rats' response to cocaine.)

Corrupting Cognition

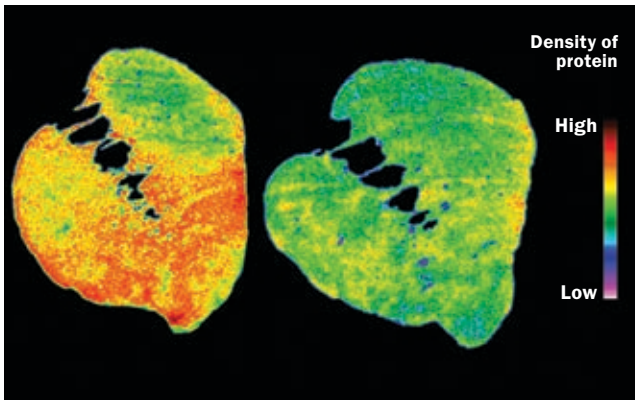
Amphetamines such as Adderall could alter the mind in other ways. A team led by psychologist Stacy A. Castner of the Yale University School of Medicine has documented long-lasting behavioral oddities, such as hallucinations, and cognitive impairment in rhesus monkeys that received escalating injected doses of amphetamine over either six or 12 weeks. Compared with monkeys given inactive saline, the drug-treated

Growing Problems

So far the best-documented problem associated with the stimulants used to treat attention-deficit hyperactivity disorder (ADHD) concerns growth. Human growth is controlled at least in part through the hypothalamus and pituitary at the base of the brain. Studies in mice hint that stimulants may increase levels of the neurotransmitter dopamine in the hypothalamus as well as in the striatum (a three-part brain structure that includes part of its reward circuitry) and that the excess dopamine may reach the pituitary by way of the bloodstream and act to retard growth.

Recent work strongly indicates that the drugs can stunt growth in children. In a 2007 analysis of a National Institute of Mental Health study of ADHD treatments involving 579 children, research psychiatrist Nora Volkow, who directs the National Institute of Drug Abuse, and her colleagues compared growth rates of unmedicated seven- to 10-year-olds over three years with those of kids who took stimulants throughout that period. Relative to the unmedicated youths, the drug-treated youths showed a decrease in growth rate, gaining, on average, two fewer centimeters in height and 2.7 kilograms less in weight. Although this growth-stunting effect came to a halt by the third year, the kids on the meds never caught up to their counterparts. —*E.S.H.*

GETTY IMAGES (*student*)



Monkeys that were trained to drink an amphetamine concoction showed subtle signs of brain damage: they had fewer transporter proteins (*right*) for processing dopamine in a region called the striatum than did untreated animals (*left*).

monkeys displayed deficits in working memory—the short-term buffer that allows us to hold several items in mind—which persisted for at least three years after exposure to the drug. The researchers connected these cognitive problems to a significantly lower level of dopamine activity in the frontal cortex of the drug-treated monkeys as compared with that of the monkeys not given amphetamine.

Underlying such cognitive and behavioral effects may be subtle structural changes too small to show up on brain scans. In a 1997 study psychologists Terry E. Robinson and Bryan Kolb of the University of Michigan at Ann Arbor found that high injected doses of amphetamine in rats cause the major output neurons of the nucleus accumbens to sprout longer branches, or dendrites, as well as additional spines on those dendrites. A decade later Castner's team linked lower doses of amphetamine to subtle atrophy of neurons in the prefrontal cortex of monkeys.

A report published in 2005 by neurologist George A. Ricaurte and his team at the Johns Hopkins University School of Medicine is even more damning to ADHD meds because the researchers used realistic doses and drug delivery by mouth instead of by injection. Ricaurte's group trained baboons and squirrel monkeys to self-administer an oral formulation of amphetamine similar to Adderall: the animals drank an amphetamine-laced orange cocktail twice a day for four weeks, mimicking the dosing schedule in humans. Two to four weeks later the researchers detected evidence of amphetamine-induced brain damage, encountering lower levels of dopamine and fewer dopamine transporters on nerve endings in the striatum—a trio of brain regions that includes the nucleus accumbens—in amphetamine-treated primates than in untreated animals [*see illustration above*]. The authors believe these observations reflect a drug-related loss of dopamine-releasing nerve fibers that reach the striatum from the brain stem.

One possible consequence of a loss of dopamine and its associated molecules is Parkinson's disease, a movement disorder that can also lead to cognitive deficits. A study in humans published in 2006 hints at a link between Parkinson's and a prolonged exposure to amphetamine in any form (not just that prescribed for ADHD). Before Parkinson's symptoms such as tremors and muscle rigidity appear, however, dopamine's function in the brain must decline by 80 to 90 percent, or by about twice as much as what Ricaurte and his colleagues saw in baboons that were drinking a more moderate dose of the drug. And some studies have found no connection between stimulant use and Parkinson's.

Stimulants do seem to stunt growth in children [*see box on opposite page*]. Otherwise, however, studies in humans have largely failed to demonstrate any clear indications of harm from taking ADHD medications as prescribed. Whether the drugs alter the human brain in the same way they alter that of certain animals is unknown, because so far little clinical data exist on their long-term neurological effects. Even when the dosing is similar or the animals have something resembling ADHD, different species' brains may have varying sensitivities to stimulant medications.

Nevertheless, in light of the emerging evidence, many doctors and researchers are recommending a more cautious approach to the medical use of stimulants. Some are urging the adoption of strict diagnostic criteria for ADHD and a policy restricting prescriptions for individuals who fit those criteria. Others are advocating behavior modification—which can be as effective as stimulants over the long run—as a first-line approach to combating the disorder. Certain types of mental exercises may also ease ADHD symptoms [see "Train Your Brain," by Ulrich Kraft; Scientific American Mind, February/March 2006]. For patients who require stimulants, some neurologists and psychiatrists have also suggested using the lowest dose needed or monitoring the blood levels of these drugs as a way of keeping concentrations below those shown to be problematic in other mammals. Without these or similar measures, large numbers of people who regularly take stimulants may ultimately struggle with a new set of problems spawned by the treatments themselves. M

(Further Reading)

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- **Amphetamine Treatment Similar to That Used in the Treatment of Adult Attention-Deficit/Hyperactivity Disorder Damages Dopaminergic Nerve Endings in the Striatum of Adult Nonhuman Primates.** George A. Ricaurte et al. in *Journal of Pharmacology and Experimental Therapeutics,* Vol. 315, No. 1, pages 91–98; October 2005.
- **Beyond Polemics: Science and Ethics of ADHD.** Ilina Singh in *Nature Reviews Neuroscience,* Vol. 9, No. 12, pages 957–964; December 2008.
- **Towards Responsible Use of Cognitive-Enhancing Drugs by the Healthy.** Henry Greely et al. in *Nature,* Vol. 456, pages 702–705; December 11, 2008.
- **Methylphenidate-Induced Dendritic Spine Formation and ΔFosB Expression in Nucleus Accumbens.** Yong Kim et al. in *Proceedings of the National Academy of Sciences USA,* Vol. 106, No. 8, pages 2915–2920; February 24, 2009.

Striving to be faultless can foster failure—or drive success—depending on the type of perfectionist you are

By Emily Laber-Warren

Can You Be *Too*

David Liu is a technology entrepreneur in San Francisco. He has helped found several start-ups to market products he has developed, including those stylus pens the UPS driver hands you to sign for your packages. But even as he dreams up new inventions, an ongoing patter in his head objects that they are stupidly obvious. And despite his accomplishments, Liu teeters on a mental precipice: "It feels shameful, like, hey, I'm in my early 30s, I should have had a Yahoo by now—or I should at least have had a company I sold for tons of money."

Liu is a perfectionist, someone who demands utmost excellence from himself, an expectation that can lead to fear of failure and reflexive self-criticism. Even when he is doing well, Liu has trouble feeling good about himself. "It's so habitual, the beating-myself-up part," he says.

Perfectionists, research shows, can become easily discouraged by failing to meet impossibly high standards, making them reluctant to take on new challenges or even complete agreed-upon tasks. The insistence on dotting all the *i*'s can also breed inefficiency, causing delays, work overload and even poor results. Perfectionism can hurt health and relationships, too. It is associated with anorexia, obsessive-compulsive disorder, social anxiety, writer's block, alcoholism and depression. Such problems may be prevalent: a 2007 study that evaluated more than 1,500 college students revealed that nearly one quarter of them suffered from an unhealthy form of perfectionism.

And yet in recent years, some psychologists have amassed evidence suggesting that perfectionism encompasses positive qualities, including a drive to succeed, an inclination to plan and organize, and a focus on excellence. Why else would people brag about the trait in job interviews? Healthy perfectionists embrace the trait's sunnier side while minimizing its darker features. Hilary Bowen, a straight-A senior at Northwestern University who made the U.S. World Cup lacrosse training team, considers herself a perfectionist. She sets the bar at the highest notch when it comes to athletics and academics. But Bowen's goals,

SERGE KROUGLIKOFF *Getty Images*

Perfect?

After a setback or disappointment, perfectionists are vulnerable to painful mood swings and a loss of self-esteem.

JUPITERIMAGES

though ambitious, are realistic, and she does not let mistakes get her down. "If I get a good grade, maybe it wasn't 100, but it was a good grade, then I see it as, 'That's awesome, that's what I wanted to do,'" she says. "But at the same time, I still push myself. I'm like, okay, I still want to get even better."

In recent years researchers have developed tools to parse and measure the beneficial, along with the detrimental, aspects of perfectionism. In addition, they are developing treatment programs that push perfectionistic tendencies in a more positive direction. Perfectionism is not an official psychiatric illness. Nevertheless, therapy not only may make the afflicted happier and more successful but may even help ameliorate associated mental illnesses, from anorexia to anxiety disorders.

FAST FACTS

Precise Advice

1» Perfectionists can become discouraged by failing to meet impossibly high standards, making them reluctant to take on new challenges or even complete agreed-upon tasks. The insistence on dotting all the *i*'s can also breed inefficiency, causing delays, work overload and even poor results.

2» Perfectionism can encompass some positive qualities, including a drive to succeed, an inclination to plan and organize, and a focus on excellence. So-called healthy perfectionists embrace the trait's sunnier side while minimizing its darker features.

3» In recent years researchers have developed tools to parse and measure the beneficial, along with the detrimental, aspects of perfectionism. In addition, they are developing treatment programs that push perfectionistic tendencies in a more positive direction.

Enemy of the Good

Psychologists have long been aware of the problems of perfectionism. In a 1980 article entitled "The Perfectionist's Script for Self-Defeat," psychiatrist and author David D. Burns wrote that perfectionism backfires when people measure their own worth entirely in terms of productivity and achievement. Vulnerable to a loss of self-esteem and painful mood swings after any setback, such people apply themselves inconsistently and ultimately accomplish less because of their perfectionism.

More recent work points to the psychological perils of unreasonable aspira-

Some people are persnickety about the neatness of their home, others about their work or personal relationships.

tions, which set people up to fail. In a 2003 study a team led by psychologist Peter J. Bieling of McMaster University in Ontario evaluated 198 students for perfectionism and then asked them what grade they wanted to get on an upcoming midterm. The perfectionists aimed for higher grades than nonperfectionists did, but on average, the two types of students performed the same on the test; the perfectionists were thus more likely to fall short of their ambitions. And rather than adjusting their expectations to reality, perfectionists who did not get the grades they wanted insisted on keeping or even raising the bar for the next exam. These high standards, rigidly upheld, can lead increasingly to feelings of failure.

Perfectionists may also adopt inefficient work habits that hurt their actual performance. They may labor slowly, agonizing over every detail, spending much more time on a project than it warrants—and often without much additional benefit. They may procrastinate, because projects that must be perfect often seem daunting [see "I'll Do It Tomorrow," by Trisha Gura; Scientific American Mind, December 2008/January 2009]. Robert Abatecola, 42, spent five years researching Victorian plastering techniques before he got around to repairing the cracked walls in his San Jose, Calif., home because he wanted to be sure to preserve the 1896 Queen Anne–style house's historical authenticity.

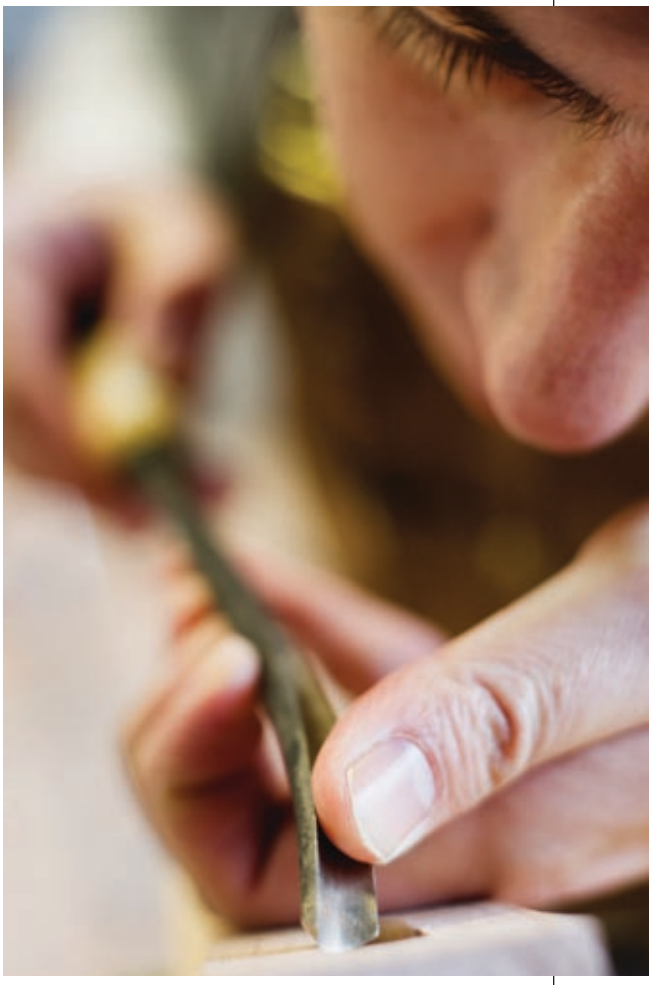
No one is a perfectionist in every situation or area of life. Some people are persnickety about the neatness of their home, others about their work, still others about their physical appearance or about relationships—for example, wanting to pen the ideal personalized note inside dozens of holiday cards every year.

Regardless, such tendencies can be especially evident when the stakes are high. In a 1990 study psychologist Randy O. Frost of Smith College and his then student Patricia A. Marten (now Marten DiBartolo and a psychologist at Smith) asked 51 female college students—some of whom scored high on a perfectionism scale—to rewrite a paragraph from a textbook, measuring their emotional state before and after the task. Highly perfectionistic students did fine when the pressure was low. But when told that their work would be evaluated and compared with that of other people, they rated the task as more important and felt worse about it than nonperfectionists did. What is more, the perfectionists' writing turned out to be inferior in general—probably because perfectionists, fearing criticism, avoid opportunities to get editing feedback and consequently do not develop their skills, the authors speculated.

As the gap between their expectations and their results widens, perfectionists may lose even more confidence, causing them to shrink from new challenges. Ironically, the more emphasis perfectionists place on excellence—the more they care—the more they may undermine their own chances of success. Psychologists Paul L. Hewitt of the University of British Columbia and Gordon L. Flett of York University in Toronto have called this phenomenon the "perfectionism paradox." As Voltaire said, "The best is the enemy of the good."

Perfectionism may spring from parents who explicitly demand that kids live up to high standards. Alternatively, children of neglectful parents may imagine that doing everything right will help them get noticed. In some cases, children living in a chaotic household may aim for perfection as a way of establishing some control over an unpredictable environment. In addition, perfectionist parents may instill the behavior by example.

Initially children may find that perfectionism works for them, says Roz Shafran, a psychologist at the University of Reading in England. "Maybe they're not getting too much attention, so they work hard in school and get rewarded for it. The harder they work, the more careful they are, the better they do," she says. "But then the situation changes. They go from school to university, where if you try



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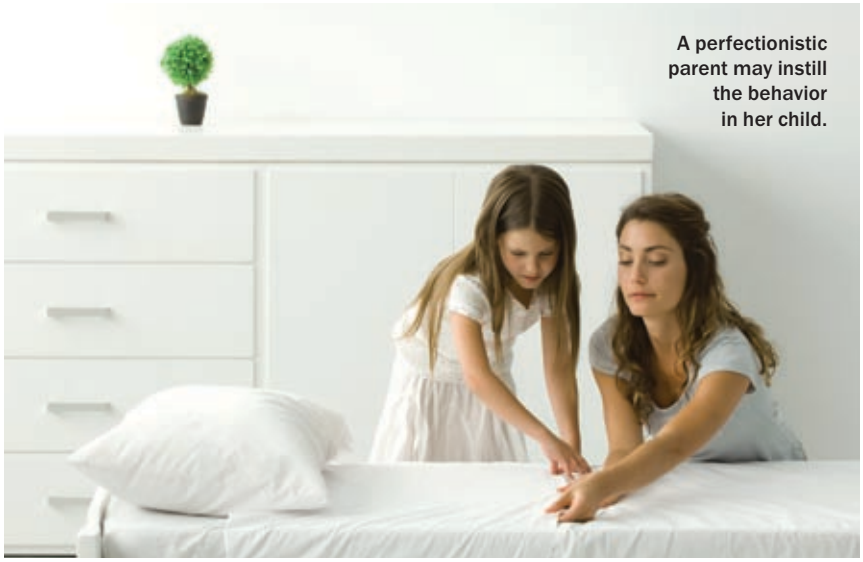
Paying excruciating attention to detail often improves the outcome but may do so at considerable cost.



A perfectionistic parent may instill the behavior in her child.

to read the entire reading list you find you can't do it and you get behind, and then you can't hand the paper in, because it's not good enough, and you're staying up all night and getting stressed."

Another way perfectionism can turn on people is if they apply it to an inappropriate area of their life, such as when a serious student decides to devote that same focus to dieting. Such devotion can lead to anorexia. [For more on the causes of anorexia, see "Addicted to Starvation," by Trisha Gura; Scientific American Mind, June/July 2008.] The trait may also alienate others. Helen Russo, 60, of West New York, N.J., still regrets times when she remade beds or refolded laundry in front of friends who had been trying to help her. Some types of perfectionism may be particularly problematic in relationships. Hewitt and Flett have developed a scale that identifies "socially prescribed" perfectionists—such individuals feel harried by the high expectations of people they care about and worry about disappointing them—and "other-oriented" perfectionists, who scrutinize those around them and bully them to do better.

Healthy Habits

Nevertheless, perfectionism has its pluses, some psychologists say. Indeed, one of the most widely used measures of the trait developed in the early 1990s by a team led by Frost assesses such arguably positive qualities as the tendencies to set high standards and to be organized, along with more problematic ones such being afraid of making mistakes and giving in to self-doubt.

The winning formula, psychologists say, is the ability to strive for excellence without being overly self-critical.

The notion that perfectionism may be a blend of positive and negative dimensions, though not endorsed by Frost, stems in part from a 1993 study of his. He and his colleagues evaluated 553 people, using both his scale and Hewitt and Flett's, and found that certain characteristics clustered together. Attributes such as being haunted by mistakes and feeling oppressed by other people's expectations were strongly correlated with one another and with depression; Frost called these "maladaptive evaluation concerns." Other tendencies, including setting high standards and striving to meet self-imposed goals, were strongly correlated with one another and with a positive outlook; Frost called this grouping "positive striving." Each individual seems to have a particular balance of these maladaptive and positive traits.

Psychologists are increasingly convinced that some strains of perfectionism can positively affect a person's well-being and success. After all, the willingness to work at something until it is just right can pay off. A person may write a better novel, have a more attractive home or build a more successful business. "A lot of good craftsmen, mechanics, surgeons probably would be considered perfectionistic," says Joachim Stoeber, a psychologist at the University of Kent in England who has published widely in the field. "If you're happy and functional, there's no reason to worry about it."

The winning formula for a perfectionist, psychologists say, is the ability to strive for excellence without being overly self-critical. Those who adopt this strategy, so-called healthy perfectionists, are relaxed and careful in their quest for success; they focus on their strengths and find great satisfaction in their achievements. Bowen, the lacrosse champ, may be one of these. So may 28-year-old Jennifer Perrone of Atlanta. In addition to her career as a wildlife biologist, Perrone sells Mary Kay cosmetics. She alphabetizes her file cabinets and labels her tool drawers; she finished planning her May 2009 wedding, literally writing the last check, the previous October. Perrone believes that she is highly effective. She does not push herself beyond what she knows she can do, and other than annoying her fiancé

GETTY IMAGES (*mother and daughter*); BRIAN KENNEDY *jupiterimages* (*shirts and ties*)

when she bugs him to take off his shoes in the house, she says, "It's difficult to think of a time when it didn't work to my benefit."

In fact, research conducted over the past 15 years has associated positive perfectionism with greater achievement, such as higher grade point averages and better performance in triathlons. Positive-striving perfectionism leads to better health and mood, more sociability and higher levels of life satisfaction. When Bieling and his colleagues separated positive perfectionists from unhealthy ones in their 2003 midterm-exam study, they found that the positive perfectionists felt better prepared for the exam and got higher grades than either unhealthy perfectionists or nonperfectionists. Olympic athletes also turned out to be positive perfectionists when assessed by Frost's test in a small survey published in 2002.

In a 2007 study Stoeber and his colleagues showed that in real-world situations, healthy perfectionism buffers people from being crushed by failure and enables them to derive more satisfaction from success. The researchers first evaluated 121 college students to determine whether they were positive perfectionists, negative perfectionists or nonperfectionists. [*To test yourself with the same tool Stoeber used, see box on next page.*] Investigators then gave the students a test that supposedly measured emotional and social intelligence—qualities, they told the students, that are important for success in life. The investigators randomly told half the participants that they had done well on the test and the others that they had received low scores. After receiving the bogus news, test takers filled out a questionnaire that measured their emotional state. Healthy perfectionists experienced more pride when informed of a high test score and fewer negative emotions when notified that they had done poorly than either the unhealthy perfectionists or the nonperfectionists.

Still, the notion that perfectionism can be positive remains controversial. Many experts argue that most people who strive for perfection have some of the attendant self-defeating concerns. "Perfectionists are more ego-involved in everything they do," Stoeber explains. A couple of studies have shown that healthy perfectionists are more depressed and neurotic than nonperfectionists are. And despite having invented the tools that inspired the term "positive perfectionism," Frost and Hewitt do not believe in it. They use other words to describe highly effective people, calling them high in conscientiousness or achievement striving.

Hillary Bowen (*right*), a lacrosse star and straight-A senior at Northwestern University, qualifies as a healthy perfectionist: she sets her sights high but does not let goofs get her down.

ALEX CENA *NCAA Photos/AP Photo*

Practicing Imperfection

Perfectionism is not a diagnosis, and few therapists treat it as a stand-alone affliction. Perfectionists are similarly unlikely to seek help, in part because the uncompromising thoughts and habits are so ingrained that individuals do not recognize their downside. Even when perfectionists do see a problem, they may be loath to change. "Who of us would want to go into treatment and come out happy with being average?" asks Tracey Wade, a psychologist at Flinders University in Australia.

But being average is not the goal; where perfectionism counseling exists, its aim is taming the trait's destructive side. At first therapists help patients recognize how the problem affects their life. Do they have difficulty making decisions because they are afraid of catastrophic repercussions if they make the wrong choice? Do they have trouble delegating at work or sharing chores at home because they do not trust that the job will get done right? Patients might keep a diary of incidents that elicit such feelings.

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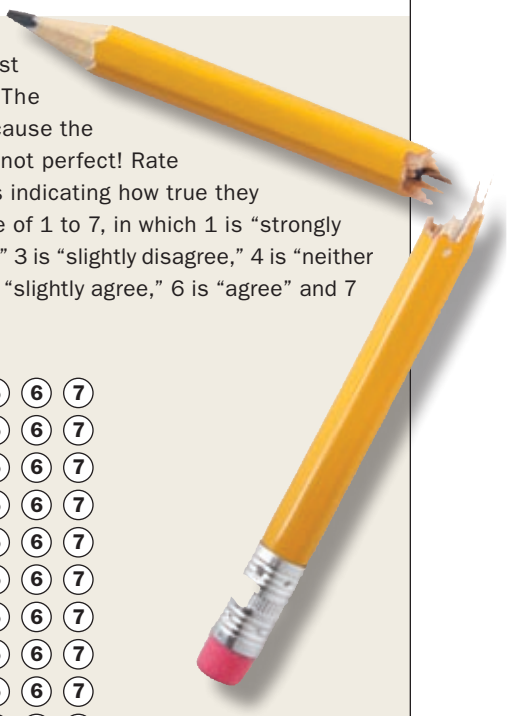
What Kind of Perfectionist Are You?

Perfectionism includes both helpful and destructive elements. Healthy perfectionists tend to be highly effective and energetic; they enjoy striving and revel in their successes. Unhealthy perfectionists, in contrast, are motivated by a fear of failure. They doubt whether they are capable of meeting the goals they have set for themselves and rarely feel satisfied with their achievements.

Take the following test, which psychologists use in research studies, to assess whether you might be a healthy perfectionist, an unhealthy perfectionist or a nonperfectionist. The "might" is important because the test, pardon the pun, is not perfect! Rate the following statements indicating how true they are for you, using a scale of 1 to 7, in which 1 is "strongly disagree," 2 is "disagree," 3 is "slightly disagree," 4 is "neither agree nor disagree," 5 is "slightly agree," 6 is "agree" and 7 is "strongly agree."



1. I have high standards for my performance at work or at school.	(1) (2) (3) (4) (5) (6) (7)
2. I often feel frustrated because I can't meet my goals.	(1) (2) (3) (4) (5) (6) (7)
3. If you don't expect much out of yourself, you will never succeed.	(1) (2) (3) (4) (5) (6) (7)
4. My best just never seems to be good enough for me.	(1) (2) (3) (4) (5) (6) (7)
5. I have high expectations for myself.	(1) (2) (3) (4) (5) (6) (7)
6. I rarely live up to my high standards.	(1) (2) (3) (4) (5) (6) (7)
7. Doing my best never seems to be enough.	(1) (2) (3) (4) (5) (6) (7)
8. I set very high standards for myself.	(1) (2) (3) (4) (5) (6) (7)
9. I am never satisfied with my accomplishments.	(1) (2) (3) (4) (5) (6) (7)
10. I expect the best from myself.	(1) (2) (3) (4) (5) (6) (7)
11. I often worry about not measuring up to my own expectations.	(1) (2) (3) (4) (5) (6) (7)
12. My performance rarely measures up to my standards.	(1) (2) (3) (4) (5) (6) (7)
13. I am not satisfied even when I know I have done my best.	(1) (2) (3) (4) (5) (6) (7)
14. I try to do my best at everything I do.	(1) (2) (3) (4) (5) (6) (7)
15. I am seldom able to meet my own high standards of performance.	(1) (2) (3) (4) (5) (6) (7)
16. I am hardly ever satisfied with my performance.	(1) (2) (3) (4) (5) (6) (7)
17. I hardly ever feel that what I've done is good enough.	(1) (2) (3) (4) (5) (6) (7)
18. I have a strong need to strive for excellence.	(1) (2) (3) (4) (5) (6) (7)
19. I often feel disappointment after completing a task because I know I could have done better.	(1) (2) (3) (4) (5) (6) (7)

SCORING

After you give a numerical response to each statement:

Add up your answers for items 1, 3, 5, 8, 10, 14 and 18. This number represents "standards"—your tendency to set ambitious goals.

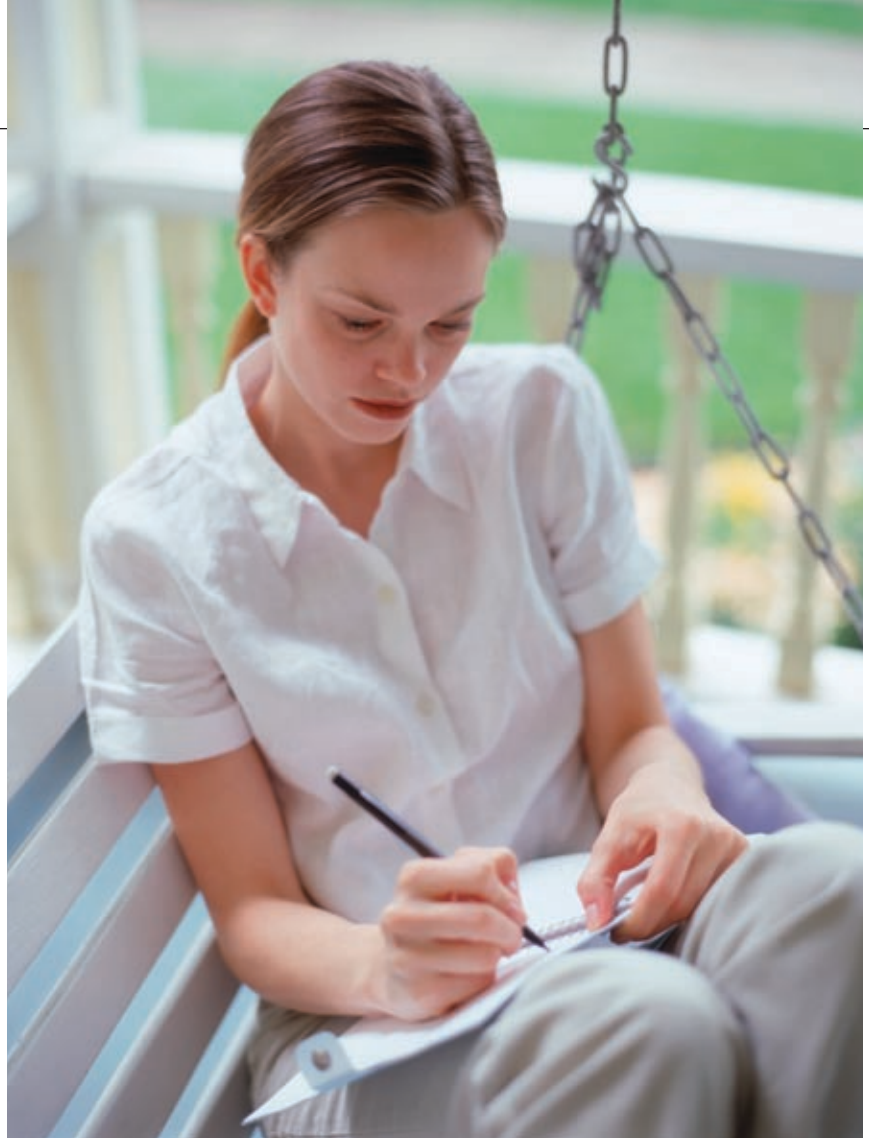
Add up your answers for the remaining items: 2, 4, 6, 7, 9, 11, 12, 13, 15, 16, 17 and 19. This number represents "discrepancy"—your sense, accurate or not, that you are not measuring up to your standards.

RESULTS

If you scored 42 or more on standards and less than 42 on discrepancy, congratulations! You may be a healthy perfectionist. You tend to focus on your goals in a Zen-like way, enjoying the pursuit of excellence while knowing that you will not reach it every time. If you scored 42 or more on standards and 42 or more on discrepancy, your perfectionism may drag you down at times. If you scored less than 42 on standards, you almost certainly scored less than 42 on discrepancy as well, and you are probably a nonperfectionist. Think Homer Simpson. If you are happy, fine. If you would like to squeeze a bit more out of yourself, then try setting your sights higher in one area of your life. Raising your standards can be motivating as long as you do not also elevate your "inner critic." —*E.L.-W.*

Adapted from the revised A*lmost Perfect Scale,* created by psychologists Robert Slaney of Pennsylvania State University, Kenneth Rice of the University of Florida, Michael Mobley of Rutgers University and Jeffrey Ashby of Georgia State University in collaboration with Joseph Trippi, then a senior consultant at SHL Landy Jacobs, Inc., in State College, Pa.

OLIVIER BLONDEAU *iStockphoto (broken pencil);* JUPITERIMAGES *(man)*



Keeping a diary of incidents that trigger perfectionistic feelings can help a therapist devise a treatment plan that combats a patient's unhealthy thought processes and behaviors.

LIZ BANFIELD *jupiterimages*

After identifying the situations that prompt a patient's perfectionism, along with the distorted thinking patterns involved, the therapist can design a treatment plan. Counselors challenge thought processes such as the belief that dwelling on mistakes is important. "You're meant to learn from your mistakes, but self-flagellation is different," Shafran says. Perfectionists may be convinced that ruminating excessively over errors is necessary to learn from them. But in fact, she says, exaggerated self-criticism keeps people stuck, preventing them from changing.

In the behavioral component of the therapy, patients practice being imperfect: they must defy one of their standards to find out whether the result is really as bad as they imagine. Shafran encourages patients to deliberately make small mistakes, such as "forgetting" to buy something on their shopping list, to learn to take blunders in stride. She also asks academically driven patients to write two essays, working as hard as they usually would on one and forcing themselves to put less effort into the other. Shafran gives the papers to a college instructor for informal grading. Typically her clients learn that the slacker paper is as good as the one they slaved over.

Preliminary data suggest such methods can ameliorate perfectionism's attendant ills. In four recent small studies by Wade, Shafran and others, as little as four to eight weeks of therapy for perfectionism reduced symptoms of obsessive-compulsive disorder, depression and bulimia—and, in 10th-grade girls, helped to diminish negative body image. Meanwhile treatment does not blunt the desire for excellence. "We seem to be able to touch the bad without also reducing the good sort of perfectionism," Wade says.

Short of serious illness, perfectionists may need informal ways to limit their fervent desire to be faultless. A first step, suggested in the 2009 book *When Perfect Isn't Good Enough,* by Martin M. Antony and his co-author Richard P. Swinson, may be to reevaluate your standards. Ask yourself, What would be the costs of relaxing these? Set specific goals for change: "Be willing to gain five pounds without getting upset" is more helpful than "Become less perfectionistic about physical appearance." Identify perfectionistic thoughts such as "I should always be entertaining and funny" and list alternatives such as "People will not judge me on the basis of one uncomfortable interaction."

Evaluate the evidence for your beliefs—say, that something tragic will happen if you perform a task imperfectly. Try to see your situation from another person's perspective; it is likely that this person would be easier on you than you are on yourself. **M**

(Further Reading)

- **Psychodynamics of Normal and Neurotic Perfectionism.** Don E. Hamachek in *Psychology,* Vol. 15, pages 27–33; 1978.
- **The Perfectionist's Script for Self-Defeat.** David D. Burns in *Psychology Today,* Vol. 14, No. 11, pages 34–52; November 1980.
- **A Comparison of Two Measures of Perfectionism.** Randy O. Frost, Richard G. Heimberg, Craig S. Holt, Jill I. Mattia and Amy L. Neubauer in *Personality and Individual Differences,* Vol. 14, No. 1, pages 119–126; 1993.
- **Positive Conceptions of Perfectionism: Approaches, Evidence, Challenges.** Joachim Stoeber and Kathleen Otto in *Personality and Social Psychology Review,* Vol. 10, No. 4, pages 295–319; 2006.
- **When Perfect Isn't Good Enough: Strategies for Coping with Perfectionism.** Second edition. Martin M. Antony and Richard P. Swinson. New Harbinger Publications, 2009.

A PATCHWORK MIND

We each have two parents, but their genetic contributions to what makes us *us* are uneven. New research shows we are an amalgam of influences from Mom and Dad

By Melinda Wenner

Your memories of high school biology class may be a bit hazy nowadays, but there are probably a few things you haven't forgotten. Like the fact that you are a composite of your parents—your mother and father each provided you with half your genes, and each parent's contribution was equal. Gregor Mendel, often called the father of modern genetics, came up with this concept in the late 19th century, and it has been the basis for our understanding of genetics ever since.

But in the past couple of decades, scientists have learned that Mendel's understanding was incomplete. It is true that children inherit 23 chromosomes from their mother and 23 complementary chromosomes from their father. But it turns out that genes from Mom and Dad do not always exert the same level of influence on the developing fetus. Sometimes it matters which parent you inherit a gene from—the genes in these cases, called imprinted genes because they carry an extra molecule like a stamp, add a whole new level of complexity to Mendelian inheritance. These molecular imprints

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silence genes; certain imprinted genes are silenced by the mother, whereas others are silenced by the father, and the result is the delicate balance of gene activation that usually produces a healthy baby.

When that balance is upset, however, big problems can arise. Because most of these stamped genes influence the brain, major imprinting errors can manifest themselves as rare developmental disorders, such as Prader-Willi syndrome, which is characterized by mild mental retardation and hormonal imbalances that lead to obesity. And recently scientists have started to suspect that more subtle imprinting errors could lead to common mental illnesses such as autism, schizophrenia and Alzheimer's disease. A better understanding of how imprinting goes awry could provide doctors with new ways to treat or perhaps even prevent some of these disorders.

Through the study of imprinted genes, researchers are also uncovering clues about how our parents' genes influence our brain—it seems that maternal genes play a more important role in the formation of some brain areas, such as those for language and complex thought, and paternal genes have more influence in regions involved in growing, eating and mating. "You need both Mom and Dad in order to get a normal brain," says Janine LaSalle, a medical microbiologist at the University of California, Davis, whose lab focuses on imprinting. "We're really at the beginning of understanding what that means."

To understand the implications of imprinting, it helps to know a few basics. Imprinting is an epigenetic (meaning "beyond genetic") mechanism, a molecular change that can happen within a cell that affects the degree to which genes are activated, without changing the underlying genetic code. The type of imprinting that happens in egg and sperm cells is known as "genomic imprinting," a reference to its fundamental heritable nature. Other types of imprinting can happen as a result of environmental influences, such as parental nurturing or abuse. [For more on epigenetics, see "The New Genetics of Mental Illness," by Edmund S. Higgins; Scientific American Mind, June/July 2008.]

> Sperm cells **silence some genes** with molecular imprints, and egg cells silence others.

As recently as a few decades ago, very few people imagined that heritable genetic influences existed beyond the basic genetic code in our DNA. Then, in 1984, biologists at the University of Cambridge and at the Wistar Institute in Philadelphia separately tried to breed mice that had either two copies of a father's chromosomes or two copies of a mother's chromosomes, instead of one copy from each parent. According to Mendelian theory, the baby mice should have been fine—after all, they had the correct number of genes and chromosomes. All the fetuses died, however, suggesting that simply having two of each chromosome is not sufficient—each pair must be made up of one chromosome from Mom and one from Dad. But the researchers did not yet know why.

Stamps of Silence

The answer is genomic imprinting, as biologists discovered in the early 1990s. In a series of papers published in *Nature* and *Genes and Development*, researchers identified the first imprinted genes in mice, all related to a protein called insulinlike growth factor 2 (IGF-2), which plays a role in regulating the size of the pups. Mouse mothers silenced this gene, resulting in smaller, easier-to-carry fetal pups, whereas mouse fathers suppressed a gene that codes for the receptor for IGF-2's protein—blocking the receptor's suppressive action so that the pups could grow larger. Since that discovery, scientists have found more than 60 human genes that are

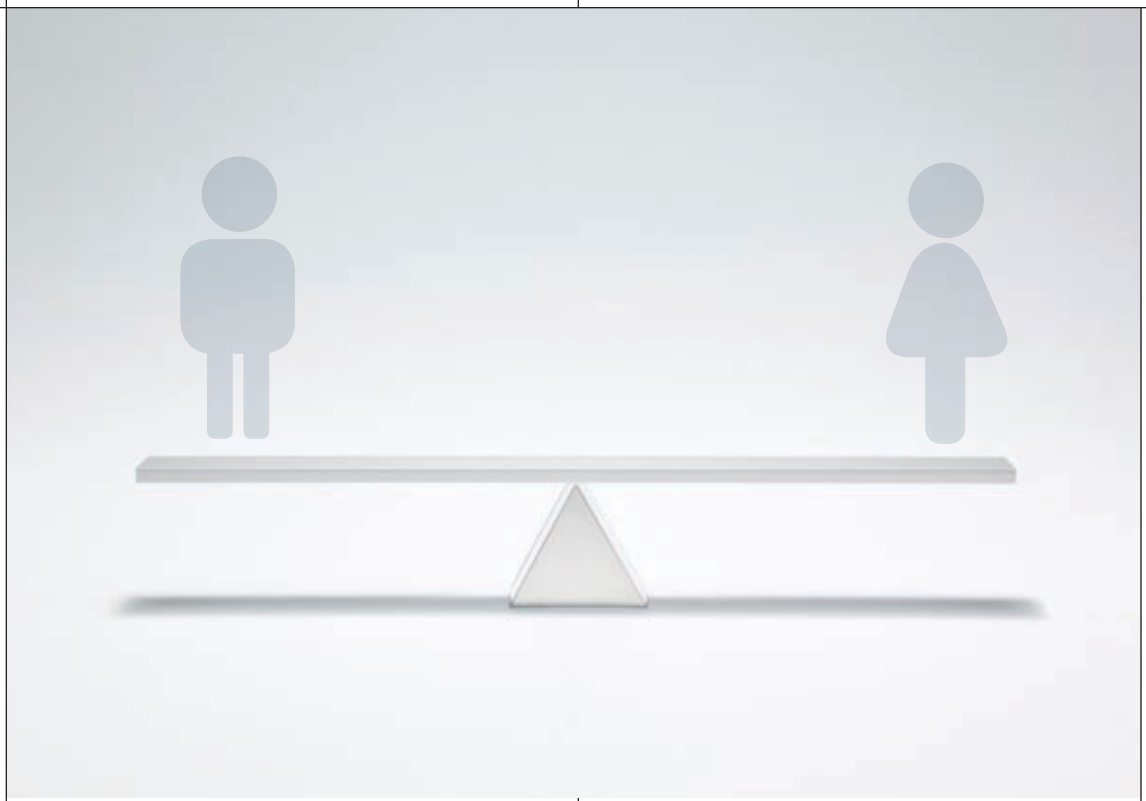
FAST FACTS

Genetic Complications

1» When passing on DNA to their offspring, mothers silence certain genes, and fathers silence others. These imprinted genes usually result in a balanced, healthy brain, but when the process goes awry, neurological disorders can result.

2» Imprinting errors are responsible for rare disorders such as Angelman and Prader-Willi syndromes, and some scientists are beginning to think imprinting might be implicated in more common illnesses such as autism and schizophrenia.

3» Even typical brains are the result of asymmetric contributions from Mom and Dad. Higher cognitive function seems to be disproportionately controlled by Mom's genes, whereas the drive to eat and mate is influenced by Dad's.



The imprinted genes we inherit from our parents exist in a delicate balance. If one parent silences more genes than the other does, the scale tips and complications arise—often affecting their child's brain and behavior.

typically imprinted by one parent or the other.

Genes are imprinted by the addition of molecules called methyl groups to the gene's DNA [*see box on next page*]. For reasons that are not totally understood, this methylation prevents the gene's information from being expressed, or transcribed into RNA and proteins, the basic building blocks of the body. It is as if the imprinting "stamp" blocks the gene's code from being read by the cell. A woman's egg carries only the genomic imprints that her mother passed on to her; her father's imprints are wiped away. Likewise, the genes that a man passes on in his sperm are imprinted in the same way that his father's genes were.

Normally, a mother's copy of a particular gene and a father's copy of the same gene are both expressed. When the genes differ (for instance, if Mom has blue eyes and Dad has brown), both genes are translated into proteins, and the end result is a combination of each gene's effects (the brown protein obscures the blue—although in reality several genes contribute to eye color). When a mother's gene is imprinted with a methyl group, however, it effectively becomes silenced—the mother's gene is then never expressed. Because only the father's gene product is being made, there is, in effect, half as much of that particular RNA or protein available to the body. Likewise, when a father's copy of a gene is imprinted, that gene is silenced, and only the mother's gene is used to make its RNA or protein.

Finding evidence of imprinting is tricky. If the two copies of a person's gene differ slightly in sequence, geneticists can analyze the RNA made from the gene to see if it, too, has two variants. If they find only one, then the gene may be imprinted, because one of the gene's copies was not expressed. If the researchers have access to the parents' DNA, they can verify which parent's gene was silenced. Because the discovery process is complex and time-consuming, scientists believe they have identified only a small fraction of the genes that are genomically imprinted. Nevertheless, many of the currently known imprinted genes influence the brain—explaining why, when imprinting goes wrong, it can cause profound effects on neurodevelopment.

Balance Skewed

Among the rare disorders that result from imprinting errors is Angelman syndrome, which affects one out of 12,000 to 20,000 children in the world. Children with the syndrome are hyperactive and often smiling and laughing. In addition, studies suggest that more than 40 percent of affected kids suffer from autism spectrum disorders as well—experiencing great difficulty with language and social skills. The syndrome is marked by a reduction of maternally expressed proteins in a small section of chromosome 15, which is also usually paternally imprinted. In other words, genes from Dad are silenced as usual, but Mom's genes are also imprinted

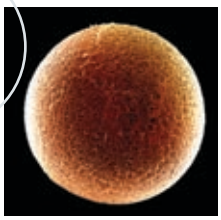
PHOTOILLUSTRATION BY SCIENTIFIC AMERICAN MIND; GETTY IMAGES (*seesaw*)

How Genes Are Silenced

With genomic imprints, both parents' DNA is modified, controlling how it affects their offspring.

1

Egg



DNA

Mom's cells silence a gene by imprinting it with a methyl group (CH_3).

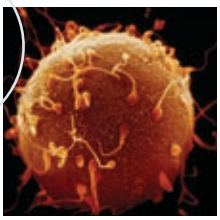
Sperm

DNA

Dad's cells silence a different gene.

2

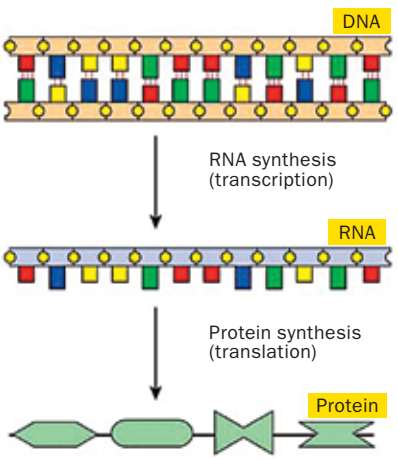
Zygote



Egg and sperm come together to form a zygote.

As the fetus develops, the genes that one parent silenced only get transcribed into RNA half as much as they would have with both parents' genes active.

During protein synthesis, a complex of previously fabricated proteins (*not shown*) reads a segment of DNA, using it to produce RNA, in a process known as transcription (*right*). Another set of molecules cooperates to translate the RNA into a protein (*lower right*).

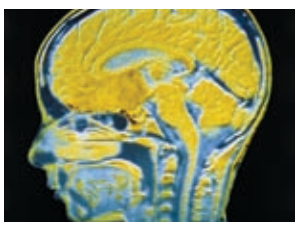


3

Fetus

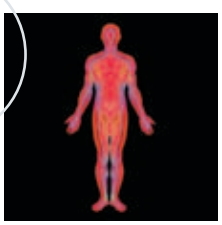
Through development and even in adulthood, the pattern of activity in your genes depends on those initial imprints from each parent.

Most of these genes are expressed in the brain.



4

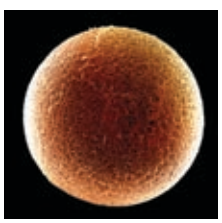
Adult



Finally, your body makes its gametes (eggs or sperm). The imprints on those cells' DNA revert back to what they were in your mother if you're female; your father if you're male.

Back to sequence 1!

Egg



Sperm

DAVID M. PHILLIPS *Photo Researchers, Inc. (egg and zygote)*; SPL/PHOTO RESEARCHERS, INC. *(sperm)*; M. A. ANSARY *SPL/Photo Researchers, Inc. (fetus)*; CNRI/SPL/PHOTO RESEARCHERS, INC. *(infant brain)*; SCOTT CAMAZINE *SPL/Photo Researchers, Inc. (adult)*; EDMUND S. HIGGINS *(DNA helices and protein synthesis diagrams)*

by mistake—they are not as active as they should be to balance Dad's imprinting effects. The brains of these children develop abnormally: their cerebral cortex is slightly smaller than usual, and a 2008 study in mice showed that cells in the cerebellum are also atypical.

When the imprinting balance is skewed in the other direction—too much net influence from Mom—another rare imprinting disorder results, called Prader-Willi syndrome, afflicting one in 10,000 to 25,000. It arises from a loss of paternal expression, caused by irregular imprinting, in the same region of chromosome 15 (although it can also result from a doubling of the mother's copy of chromosome 15). Magnetic resonance imaging studies of children with Prader-Willi syndrome reveal anomalies in the structure of their pituitary gland, a relatively small brain stem and atrophy in the cerebral cortex. Children with the disorder are mildly mentally retarded and exhibit hormonal problems, which often lead them to become obese as teenagers and adults.

Some scientists posit that imprinting problems are responsible for more than just rare developmental disorders. They could contribute to common mental illnesses that plague our society today, such as autism and schizophrenia. Sociologist Christopher Badcock of the London School of Economics, for instance, has a personal interest in autism that led him and his colleagues to investigate imprinting's effects on the disorder.

Opposite Disorders

Badcock has always thought that he sits a little closer to the autism side of the spectrum than most people do. "Modern diagnostic instruments suggest that quite a large proportion of the population is like this—particularly males," he explains. "The more I read about autism, the more I couldn't help noticing, I was probably one of those people, too." Over the years Badcock's interest in autism spawned a radical idea. "It suddenly struck me that there's this remarkable symmetry between the symptoms of autism and the symptoms of paranoid schizophrenia," he recalls. Autism, which translates from Latin roughly into "self-orientation," is characterized by impaired social interaction, gaze detection and language development. Psychotic disorders such as schizophrenia, on the other hand, can be considered the opposite: the lack of a sense of self in autism can be contrasted with megalomania often found in people with psychoses.

One day in 1993, while riding a commuter train in London, Badcock stumbled on an article in *New Scientist* about the role of imprinting in the expression of the gene for IGF-2, the protein that can affect a baby's size. Badcock suddenly realized that "insights into genomic imprinting could explain a lot about mental illness and whether you ended up autistic or psychotic," he says.

When imprinting goes wrong, it **can cause profound effects** on neurodevelopment.

Badcock and evolutionary biologist Bernard Crespi of Simon Fraser University in British Columbia have since developed this theory, having most recently published an essay in *Nature* on the potential role that genomic imprinting plays in autism and psychotic disorders. "These disorders are opposites to one another, and imprinting is one of the mechanisms that can mediate that opposing feature," Crespi posits. Although imprinting usually builds a balanced brain, if one parent's contribution outweighs the other's, then autism spectrum disorders (the result of too much net paternal influence, they argue) or psychosis (the result of too much net maternal influence) may instead develop, they say.

Circumstantial evidence supports their theory. Autism is characterized by high birth weight, which one might expect if autism were caused by an overly paternally influenced brain, given the link between imprinting and growth-regulating genes. In addition, Angelman syndrome is marked by a larger net paternal influence, and 40 percent of Angelman sufferers also develop autism. Another rare disorder, Beckwith-Wiedemann syndrome, can be caused by several different alterations to a region along chromosome 11, one of which involves replacing the maternal copy of this region with an extra paternal copy. Children with this disease have a 10-fold increased risk of autism, according to a study published in 2008 by researchers at the University of St. Andrews in Scotland—suggesting yet again a link among imprinting, too much relative

(The Author)

MELINDA WENNER is a freelance science writer based in Brooklyn, N.Y.

Battle of the Sexes

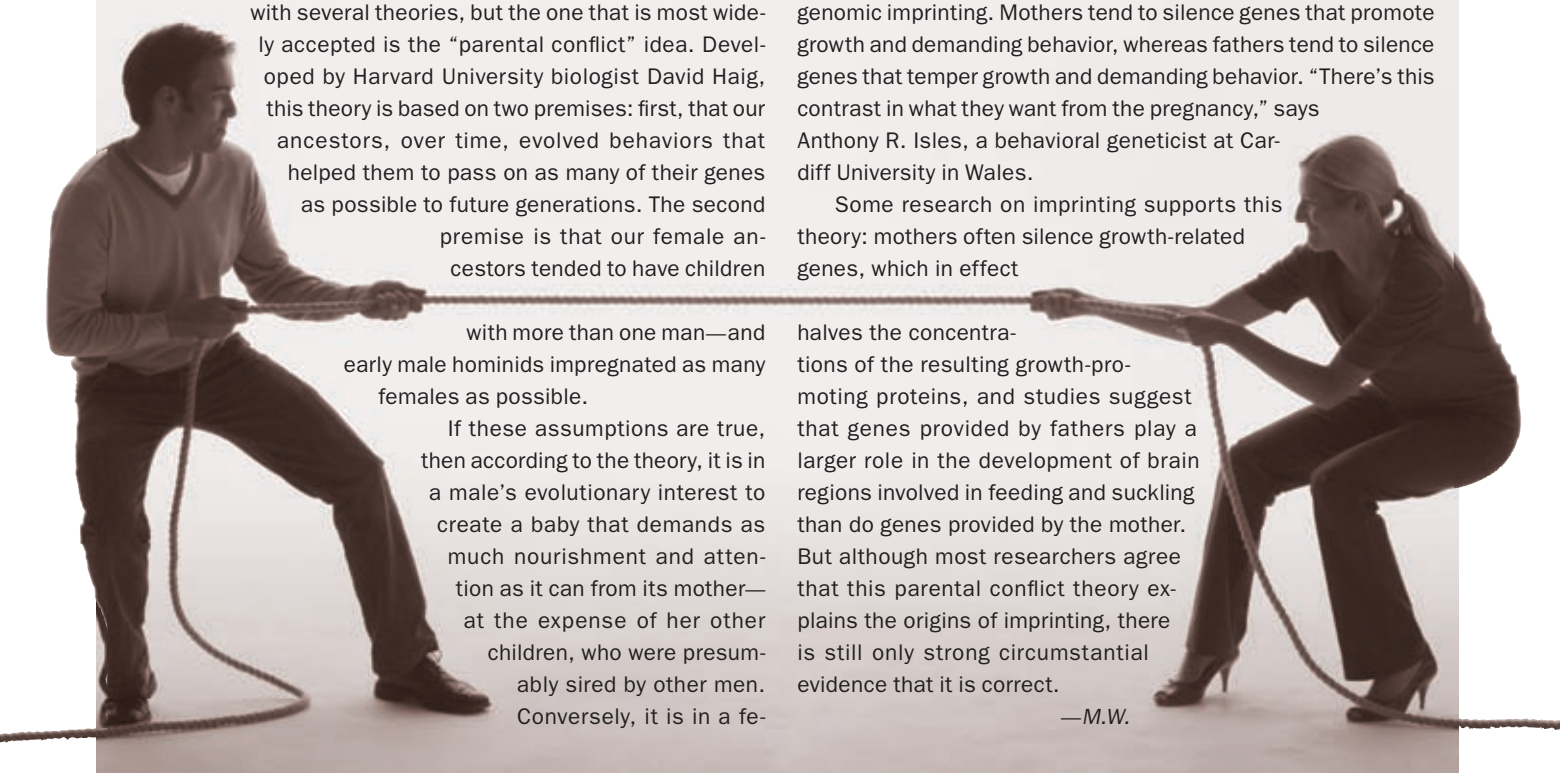
Genomic imprinting, in which certain genes are silenced by mothers and others by fathers, adds a layer of complexity to the traditional idea of inheritance. When imprinting goes awry, it causes terrible neurological problems—so why did it evolve in the first place? Evolutionary biologists have come up with several theories, but the one that is most widely accepted is the "parental conflict" idea. Developed by Harvard University biologist David Haig, this theory is based on two premises: first, that our ancestors, over time, evolved behaviors that helped them to pass on as many of their genes as possible to future generations. The second premise is that our female ancestors tended to have children with more than one man—and early male hominids impregnated as many females as possible.

If these assumptions are true, then according to the theory, it is in a male's evolutionary interest to create a baby that demands as much nourishment and attention as it can from its mother—at the expense of her other children, who were presumably sired by other men. Conversely, it is in a female's best interest to have children that are not overly demanding, because her goal is to distribute her resources equally among all her children so that they have the same chance of surviving.

These opposing forces, Haig says, battle each other through genomic imprinting. Mothers tend to silence genes that promote growth and demanding behavior, whereas fathers tend to silence genes that temper growth and demanding behavior. "There's this contrast in what they want from the pregnancy," says Anthony R. Isles, a behavioral geneticist at Cardiff University in Wales.

Some research on imprinting supports this theory: mothers often silence growth-related genes, which in effect halves the concentrations of the resulting growth-promoting proteins, and studies suggest that genes provided by fathers play a larger role in the development of brain regions involved in feeding and suckling than do genes provided by the mother. But although most researchers agree that this parental conflict theory explains the origins of imprinting, there is still only strong circumstantial evidence that it is correct.

—*M.W.*



AGE FOTOSTOCK

paternal influence and autism spectrum disorders.

Although there is no direct evidence that psychotic illnesses such as schizophrenia and bipolar disorder are the result of abnormal genomic imprinting in the other direction, there are nonetheless interesting hints of such a connection. For example, almost all children with Prader-Willi syndrome suffer from psychotic disorders.

Nondevelopmental diseases have been linked to imprinting in recent years, too. A study published in the *American Journal of Medical Genetics* in 2002 by Johns Hopkins University researchers reported that the gene variants that predispose people to late-onset Alzheimer's most often come from the mother, which could implicate imprinting. A study published in 1995 in the same journal found that bipolar disorder is also transmitted preferentially from the mother, and a study published in *Neurology* in 1997 found that Tourette's disorder has different symptoms and develops later if it is inherited from the father rather than from the mother—suggesting again (yet not proving) that imprinting may play a role in their development. "There are lots of dots that need to be connected still," says Jon Wilkins, an evolutionary theorist at the Santa Fe Institute.

If imprinting is solidly linked to the development of common mental disorders, then it may one day be appropriate to treat patients with drugs that manipulate gene expression. One method could be dialing down the activity of targeted genes, using a therapy called RNA interference—because it interferes with gene expression. A version of RNA interference that lowers the expression of growth-related tumor genes is currently being tested in a clinical trial in California and Texas. And two U.S. Food and Drug Administration–approved drugs for blood cell disorders, decitabine and azacitidine, prevent methyl groups from being added to genes in blood cells, demonstrating that this approach might help correct imprinting errors in other tissues as well. Although many effects of imprinting errors manifest themselves in the womb, treating imbalanced gene expression after birth could also reduce or eliminate some symptoms in these developmental diseases.

As scientists uncover imprinting's role in mental illness, they are also revealing some intriguing

asymmetries in each of our parents' contributions to our brain and behavior. In two landmark studies published in 1995 in the *Proceedings of the National Academy of Sciences USA* and in 1996 in *Developmental Brain Research,* Cambridge developmental biologist E. Barry Keverne and his colleagues discovered that certain brain regions are almost entirely controlled by the mother's genes and other regions by the father's. After the researchers created normal mouse embryos consisting of only a few cells, they combined them in a petri dish with two-celled embryos comprising either solely paternal or solely maternal chromosomes. The resulting fetuses consisted of either mostly paternally or mostly maternally expressed genes.

The mice with more paternal influence had smaller brains and larger bodies, and brain cells grew abundantly in the hypothalamus and septum—areas that maintain energy balance and mediate behaviors such as food seeking, mating, emotional expression and social aggression. Conversely, mice bred with more maternal influence had smaller bodies and larger brains—especially forebrains and regions that are involved in intelligence, complex emotional responses, planning and problem solving.

> Certain brain regions are **almost entirely controlled** by the mother's genes, and other regions by the father's.

Like Father, Like Son

These findings suggest that Dad's genes play a bigger role in the development of instinctual behaviors, such as feeding and mating, whereas Mom's genes are more concentrated on the development of higher-order cognition. "The maternal influence is more on language and social executive function aspects of the brain, which are, in a sense, more complex," LaSalle explains.

Psychological research in humans also bolsters these data. In a 2006 study published in the *Journal of Neurogenetics,* psychologists at Baycrest Hospital in Toronto recruited families composed of an adult brother and sister and their biological parents. The researchers gave them tests made up of tasks that depended on particular brain regions. The siblings performed much like their mothers did on tasks that involved the frontal and parietal lobes and the hippocampus, suggesting that skills using those areas come from the mothers. The authors admit, however, that kids might also resemble their mothers in these types of skills because of how much time they spend with their moms during childhood.

What is irrefutable, however, is that genomic imprinting has overturned some of the most basic tenets of biology. A century's worth of research in genetics, developmental biology and neuroscience was based on inheritance concepts that are simply not true—which means that we know far less about the brain than we thought we did. "We've got a bunch of new stuff that, fundamentally, we don't even know how to get our minds around," Wilkins admits. We can no longer think of ourselves as rough composites of our parents but rather as intricate puzzles crafted from thousands of maternal and paternal pieces over the course of evolution. And once we identify all the parts—which will be a huge challenge in itself—we will then need to decipher how they fit together. "It's just going to take time," Wilkins says. M

BSIP/PHOTO RESEARCHERS, INC.

Mice with more paternal genes have brains with healthy food- and sex-related areas but abnormally small regions involved in problem solving, intelligence and planning. Maternally influenced mice are the opposite.

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AGE FOTOSTOCK

Do Parents Matter?

A researcher argues that peers are much more important than parents, that psychologists underestimate the power of genetics and that we have a lot to learn from Asian classrooms

INTERVIEW BY JONAH LEHRER

NOMI L. HARRIS (*Harris*)

In 1998 Judith Rich Harris (left), *an independent researcher and textbook author, published* The Nurture Assumption: Why Children Turn Out the Way They Do. *The book provocatively argued that parents matter much less—at least when it comes to determining the behavior of their children—than is typically assumed. Instead Harris argued that a child's peer group is far more critical.* The Nurture Assumption *has recently been reissued in an expanded and revised form (Free Press, 2009).* Scientific American Mind *contributing editor Jonah Lehrer chatted with Harris about her critics, the evolution of her ideas and why teachers can be more important than parents.*

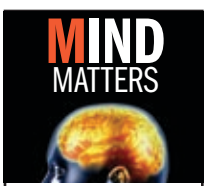
SCIENTIFIC AMERICAN MIND: Freud famously blamed the problems of the child on the parents. (He was especially hard on mothers.) In *The Nurture Assumption,* an influential work that was published 10 years ago, you argued that parents are mostly innocent and that peers play a much more influential role. What led you to write the book?

JUDITH RICH HARRIS: It wasn't just Freud! Psychologists of all persuasions, even behaviorists such as B. F. Skinner, thought the parents were responsible, one way or the other, for whatever went wrong with a child. One of my purposes in writing the book was to reassure parents. I wanted them to know that parenting didn't have to be such a difficult, anxiety-producing job, that there are many different ways to rear a child, and that no convincing evidence existed that one way produces better results than another.

But my primary motive was scientific. During the years I spent writing child development textbooks for college students, I never questioned the belief that parents have a good deal of power to shape the personalities of their children. (This is the belief I now call the "nurture assumption.") When I finally began to have doubts and looked more closely at the evidence, I was appalled. Most of the research is so deeply flawed that it is meaningless. And studies using more rigorous methods produce results that do not support the assumption.

MIND: How did the field react?

HARRIS: The initial reaction was far off the mark. Professors of psychology were asked to give their opinion of the book before they'd had a chance to read it, so their comments were based on what they had heard about it. Many of them responded by saying that "Harris has ignored a great deal of evidence." But when pressed to specify the evidence I had ignored, they'd name the very same kinds of studies I



This article was adapted from Mind Matters, www.ScientificAmerican.com/MindMatters, where researchers explain their discipline's most notable recent findings. Mind Matters is edited by Jonah Lehrer, the science writer behind the blog The Frontal Cortex, http://scienceblogs.com/cortex

According to Harris, peers pay a vital role in shaping a child's personality and behavior.

ADRIAN WEINBRECHT *Getty Images*

had mercilessly dissected in the book. Or they'd tell the journalist about a study that hadn't yet been published but that, when published, would prove that Harris was wrong. My attempt to track down those unpublished studies is described in my second book, *No Two Alike* [W. W. Norton, 2006].

As time went on, the professors calmed down. Some of them began to listen to what I was saying, perhaps because I was also publishing articles in academic journals. My work is now cited in many psychology textbooks and assigned in college courses. Of course, most developmental psychologists still don't agree with me, but at least they're acknowledging that there's another point of view.

There has also been some improvement in research methodology, not because of my nagging but because of a greater awareness of genetic influences on personality. It's no longer enough to show, for example, that parents who are conscientious about child rearing tend to have children who are conscientious about their schoolwork. Is this correlation the result of what the children learned from their parents or of the genes they inherited from them? Studies using the proper controls consistently favor the second explanation. In fact, personality resemblances between biological relatives are attributable almost entirely to heredity, rather than environment. Adopted children don't resemble their adoptive parents in personality. I'm not particularly interested in genetic effects, but the point is that they have to be taken into account. Unless we know what the child brings to the environment, we can't figure out what effect the environment has on the child.

MIND: Why do you think this is such a controversial idea? In other words, why are we so convinced that parents must matter?

HARRIS: It's part of the culture. Questioning a cherished cultural myth is always risky. What most people don't realize is that different cultures have different myths about the role of parents. The belief that parents have a great deal of power to determine how their children will turn out is actually a rather new idea. Not until the middle of the last century did ordinary parents start believing it. I was born in 1938, before the cultural change, and parenting had a very different job description back then. Parents didn't feel they had to sacrifice their own convenience and comfort to gratify the desires of their children. They didn't worry about boosting the self-esteem of their children. In fact, they often felt that too much attention and praise might spoil them and make them conceited. Physical punishment was used routinely for infractions of household rules. Fathers provided little or no child care; their chief role at home was to administer discipline.

All these things have changed dramatically in the past 70 years, but the changes haven't had the expected effects. People are the same as ever. Despite the reduction in physical punishment, today's adults are no less aggressive than their grandparents were. Despite the increase in praise and physical affection, they are not happier or more self-confident or in better mental health. It's an interesting way to test a theory of child development: persuade millions of parents to rear their children in accordance with the theory and then sit back and watch the results come in. Well, the results are in, and they don't support the theory!

MIND: Have your ideas changed at all since writing the book?

HARRIS: They've expanded rather than changed. I've filled in some holes. A few years after the first

As children become socialized, their behavior becomes more similar to their **same-sex peers**.

edition of *The Nurture Assumption* was published, I realized that the theory proposed in that book, Group Socialization Theory, was incomplete. It does a good job of explaining socialization—the way children acquire the behaviors, skills and attitudes approved by their culture—but a poor job of explaining personality development. As children become socialized, their behavior becomes more similar to that of their same-sex peers. But differences in personality don't go away—if anything, they widen. Group Socialization Theory doesn't explain, for example, why identical twins have different personalities, even if they're reared in the same home and belong to the same peer group. That's the puzzle I tackled in *No Two Alike*. The expanded version of the theory is based on the idea that the human mind is modular and that it consists of a number of components, each designed by evolution to perform a specific job, and that three different mental modules are involved in social development. The first deals with relationships, including parent-child relationships. The second handles socialization. The third enables children to work out a successful strategy for competing with their peers, by figuring out what they are good at.

MIND: You emphasize the importance of teachers in shaping a child's development. How can we apply this new theory of child development to public policy?

HARRIS: I've put together a lot of evidence showing that children learn at home how to behave at home (that's where parents do have power!), and they learn outside the home how to behave outside the home. So if you want to improve the way children behave in school—for instance, by making them more diligent and less disruptive in the classroom—then improving their home environment is not the way to do it. What you need is a school-based intervention. That's where teachers have power. A talented teacher can influence a whole group of kids.

The teacher's biggest challenge is to keep this group of kids from splitting up into two opposing factions: one proschool and prolearning, the other antischool and antilearning. When that happens, the differences between the groups widen: the proschool group does well, but the antischool group falls further and further behind. A classroom with 40 kids is more likely to split up into opposing groups than one with 20, which may explain why students tend to do better in smaller classes. But regardless of class size, some teachers have a knack for keeping their classrooms united. Teachers in Asian countries seem to be better at this than Americans, and I suspect this is one of the reasons why Asian kids learn more in school. No doubt there's a difference in cultures, but maybe we could study how they do it and apply their methods here.

The tendency of kids to split up spontaneously into subgroups also explains the uneven success rate of programs that put children from disadvantaged homes into private or parochial schools. The success of these programs hinges on numbers. If a classroom contains one or two kids who come from a different background, they assimilate and take on the behaviors and attitudes of the others. But if there are five or six, they form a group of their own and retain the behaviors and attitudes they came in with.

President Obama has promised to restore science to its rightful place. I hope he realizes that its rightful place doesn't have to be a laboratory. It can also be a school classroom. M

A challenge for teachers is keeping their classrooms socially united, rather than letting kids break into factions that can be disruptive for learning.

AGE FOTOSTOCK

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What Do We Know about Tourette's?

If you have the idea that every patient curses unpredictably, think again

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

ON MAY 22, 2001, radio talk show personality Laura Schlessinger, better known as Dr. Laura, received a call from a woman who was distressed by her sister's decision to exclude their nephew from an upcoming family wedding. When the caller mentioned that the boy suffered from Tourette's disorder (also sometimes called Tourette syndrome), Dr. Laura berated her for even thinking that it might be appropriate to invite a child who would "scream out vulgarities in the middle of the wedding." As we'll soon explain, Dr. Laura's comments embody just one of several common myths regarding Tourette's.

Tourette's disorder is the eponymous name for the condition first formally described in 1885 by French neurologist Georges Gilles de la Tourette, who dubbed it *maladie des tics* ("sickness of tics"). According to the current edition of the American Psychiatric Association's diagnostic manual, Tourette's disorder is marked by a history of both motor (movement) tics and phonic (sound) tics.

Motor tics include eye twitching, facial grimacing, tongue protrusion, head turning and shrugging of the shoulders, whereas phonic tics encompass grunting, coughing, throat clearing, yelling inappropriate words and even barking. Some tics are "complex," meaning they are coordinated series of actions. For example, a Tourette's patient might continually pick up and smell objects or repeat what someone else just said (echolalia). Often a tic is preceded by a "premonitory urge"—that is, a powerful desire to emit the tic, which some have likened to the feeling we experience immediately before sneezing. Tourette's patients typically report short-term relief following the tic.

Tourette's generally emerges at about age six or seven, with motor tics usually appearing before phonic tics. In rare cases, the disorder disappears by adulthood. Data suggest that it may be present in one to three out of 1,000 children; about three to four times as many males as females are affected.

Myths and Realities

As the Dr. Laura incident demonstrates, Tourette's disorder is the subject of popular misconceptions; we'll examine the four that are most widespread.

Misconception 1: *All Tourette's patients curse.* In a survey of undergraduates by University of San Diego psychologists Annette Taylor and Patricia Kowalski, 65 percent endorsed this view. In fact, coprolalia, the use of curse words, and copropraxia, the use of obscene gestures, occur in only a minority—probably about 10 to 15 percent—of Tourette's patients. But because these symptoms are so dramatic, they plant themselves firmly in observers' memories. They also garner the lion's share of media attention, as in a 2002 *Curb Your Enthusiasm* episode featuring a chef with Tourette's disorder, who curses uncontrollably in front of his customers.

Misconception 2: *Tourette's symptoms are voluntary.* Because Tourette's sufferers can often suppress their tics for brief periods, some have concluded mis-

(Often a tic is preceded by a **"premonitory urge,"** which some have likened to the feeling we experience before sneezing.)

COURTESY OF SCOTT O. LILIENFELD (*top*); COURTESY OF HAL ARKOWITZ (*bottom*); FELIX CLINTON Getty Images (*woman*)

takenly that patients generate them of their own accord. In fact, they have little or no control over premonitory urges and can inhibit tics only for so long, just as you can only briefly avoid scratching an itch. Moreover, tic suppression typically results in a later "rebound" of tics.

Misconception 3: *Tourette's disorder is caused by underlying psychological conflict.* As medical historian Howard Kushner, now at Emory University, noted, the idea that Tourette's results from deep-seated psychological factors held sway in American psychiatry for much of the 20th century. As recently as the mid-1980s, one of us (Lilienfeld) was told by a psychologist in training that the tics of Tourette's patients represented symbolic discharges of repressed sexual energies. Today we know that the disorder is substantially heritable. A 1985 study by R. Arlen Price, then at Yale University, and his colleagues found that in identical twins (who share virtually all of their genes) with Tourette's, both twins had the disorder 53 percent of the time, whereas in fraternal twins (who share half their genes on average) with Tourette's, both twins had the disorder only 8 percent of the time. Still, stress can increase tic frequency, so genes are unlikely to tell the whole story. Brain-imaging studies of Tourette's patients reveal abnormalities in areas related to movement, such as the basal ganglia, a collection of structures buried deep in the cerebral hemispheres.

Misconception 4: *People with Tourette's are incapacitated by their symptoms.* Many individuals with Tourette's function successfully in society. Mort Doran, a Canadian surgeon with Tourette's, manages to suppress his tics while in the operating room; he is also an amateur pilot. Neurologist Oliver Sacks wrote of a jazz drummer who reported that his Tourette's disorder enhanced his musical performances by imbuing them with energy. Indeed, some have argued that Tourette's can be a blessing rather than a curse, perhaps in part because the condition forces people to learn impulse-control skills that few of us acquire. This claim is intriguing but anecdotal. Former National Basketball Association point guard Chris Jackson, who changed his name to Mahmoud Abdul-Rauf, said that his Tourette's made him focus with laserlike precision on his shooting. He twice led the league in free-throw percentage; during one stretch of play in 1993, he made 81 consecutive free throws.

Hope for Tourette's Sufferers

There is no known cure for Tourette's, but several treatment options exist. Medications such as Haldol (generic name haloperidol) and Orap (generic name pimozide), which block the action of the chemical messenger dopamine, have been found in studies to be effective in reducing the frequency and intensity of tics. Other promising medications are clonidine, which doubles as a blood pressure drug, and botulinum toxin, better known as Botox. Clonidine inhibits the chemical messenger norepinephrine, which some researchers have argued is implicated in Tourette's. Although Botox's mechanisms of action on Tourette's are unknown, it appears to work by blocking body processes that are involved in facial tics or movement.

Preliminary evidence suggests that some behavioral therapies, especially habit reversal, can be helpful for Tourette's disorder; it is not known whether combining these techniques with medication yields an additive benefit. Habit reversal teaches patients to become aware of the premonitory urges preceding tics and to learn and practice muscular actions incompatible with their tics. For example, a patient who repeatedly jerks his arm violently toward others might be taught to direct his arm slowly toward his head, culminating in touching his hair gently. This approach and others are not panaceas, but they can help some Tourette's patients to bring their more troubling symptoms under better control. M

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

Send suggestions for column topics to editors@SciAmMind.com

Tourette's through History

Some writers have argued that several famous historical figures, including Roman emperor Claudius (of *I, Claudius* fame, *left*) and author Samuel Johnson, may have had Tourette's disorder. Others have speculated that composer Wolfgang Amadeus Mozart (*right*) had Tourette's, although the evidence here is more circumstantial, consisting mostly of suggestions that Mozart was prone to profanity and to hyperactivity, a symptom that commonly occurs with Tourette's.

Psychiatrist Arthur K. Shapiro and psychologist Elaine Shapiro of Cornell University conjectured that the troubled girl who formed the basis for the 1971 book and 1973 blockbuster film *The Exorcist* had Tourette's disorder. Some observers, they contend, misinterpreted her head jerking, grunting and profane language as hallmarks of demonic possession. —*S.O.L. and H.A.*

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Try a Little Powerlessness

We admire self-discipline, but could too much control be a bad thing?

BY WRAY HERBERT

SELF-CONTROL is one of our most cherished values. We applaud those who have the discipline to regulate their appetites and actions, and we try hard to instill this virtue in our children. Think of the marketing slogans that key off the desire for restraint: "Just say no." "Just do it." We celebrate the power of the mind to make hard choices, despite our emotions or other temptations, and keep us on course.

But what if we can't just do it? What if "it" is too difficult or if our strategy for success is misguided? Is it possible that willpower actually might be an obstacle rather than a means to happiness and harmony? Can we have too much of a good thing?

Two Tufts University psychologists believe there may be some truth to this possibility. Evan P. Apfelbaum and Samuel R. Sommers were intrigued by the notion that too much self-control may indeed have a downside—and that relinquishing some personal power might be paradoxically tonic, both for individuals and for society. They decided to test this idea in the laboratory.

We celebrate the power of the mind over our bodies and appetites.

MATT MENDELSON (*Herbert*); PATRIK GIARDINO/*jupiterimages* (*gymnast*)

Your Inner Bigot

They explored the virtue of powerlessness in the arena of race relations. They figured that well-intentioned people are careful—sometimes hypercareful—not to say the wrong thing about race in a mixed-race group. Furthermore, they thought that such effortful self-control might actually cause both unease and dishonesty, which could in turn be misconstrued as racial prejudice.

To test this theory, they first deliberately sapped the mental powers of a number of volunteers. This practice is not as diabolical as it sounds. Researchers ran the participants through a series of computer-based mental exercises that are so challenging that the subjects temporarily

(Is it possible that willpower actually might be an obstacle rather than **a means to happiness** and harmony?)

> Race relations is **just one arena** of our life where a little powerlessness might go a long way.

deplete their cognitive reserves needed for discipline. Once they had the volunteers in this compromised state of mind, they put the group (and others who were not so depleted) into a social situation with the potential for racial tension. Here it is:

Each white subject is left alone in a room. A black man enters and asks if the volunteer will consent to a brief interview on the issue of how universities should guarantee racial diversity. This question is ostensibly unrelated to the self-control experiment, but in fact that is a ruse. The interviewer asks the participant to share any thoughts he or she might have on this "hot topic," and the conversation is recorded.

It was that simple, although sometimes the interviewers were white, to serve as controls. Afterward, the volunteers rated the interaction for comfort, awkwardness and enjoyment. In addition, independent judges—both black and white—analyzed the five-minute interactions, commenting on how cautious the volunteers were, how direct in their answers, and how racially prejudiced.

In a study, white subjects who had been mentally fatigued were less inhibited while talking to black interviewers—and both parties enjoyed the conversation more.

DON MASON *Corbis*

Failure of Control

The results were provocative. As reported in the February issue of the journal *Psychological Science*, those who were mentally depleted—that is, those who did not have the energy to exert personal discipline and self-control—found talking about race with a black man much more enjoyable than did those whose self-control was intact. That outcome is presumably because they were not working so hard at monitoring and curbing what they said. It may seem counterintuitive, but being cognitively drained made them less inhibited and more candid, which felt good.

And it wasn't just the volunteers' perceptions of the experience: the independent black observers found that the powerless volunteers were much more direct and authentic in conversation. And perhaps most striking, blacks saw the less inhibited whites as less prejudiced against blacks. In other words, relinquishing power over oneself appears to thwart overthinking and "liberate" people for more authentic relationships.

Race relations is just one arena of life where a little powerlessness may go a long way. Addiction recovery is another. One of the guiding principles of 12-step programs is that too much self-reliance can be harmful and that powerlessness is a necessary precursor of the emotional balance needed for sobriety. But self-reliance is so deeply ingrained in us that it pervades our work lives, our relationships and our health choices, so it is a real challenge to accept that it might sometimes be a character flaw. It is good to remember that the volunteers here were not only perceived as fairer; they themselves felt happier. Where else might we be acting too smart for our own good? M

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

WRAY HERBERT is director of public affairs for the Association for Psychological Science.

(Further Reading)

◆ **Liberating Effects of Losing Executive Control.** Evan P. Apfelbaum and Samuel R. Sommers in *Psychological Science*, Vol. 20, No. 2, pages 139–143; February 2009.

books: Origins

Why do we see in color? How did language evolve? What drove the development of our enormous brain? Several new books delve into the mysteries of human evolution:

The Vision Revolution: How the Latest Research Overturns Everything We Thought We Knew about Human Vision

by Mark Changizi. Benbella Books, 2009 ($24.95)

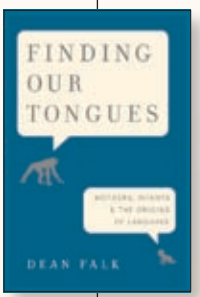
Ever wanted to feel like a superhero—able to read people's emotions, see through objects and predict the future? Well, you're in luck. According to Mark Changizi in *The Vision Revolution,* you can already perform all these feats—thanks to the exceptional power of your two eyes.

Changizi, a cognitive scientist at Rensselaer Polytechnic Institute, approaches the field of vision from a different perspective than most scientists do: he is interested not in how our eyes work but in why they work the way they do. Why, for instance, did primates evolve color vision, whereas other animals did not? Changizi argues that color vision did not evolve to help us pick out edible leaves or fruits—a theory that has held ground for decades—but rather that we began to see greens, blues, reds and yellows because doing so helped us to distinguish among hues of skin. Skin color changes slightly when we are happy, angry, embarrassed or sick, and our primate ancestors' ability to detect these subtle changes helped them socially.

In case overturning one venerable hypothesis isn't enough, Changizi offers more: for instance, our eyes face forward to help us see "through" objects, he argues. The fields of vision from each of our eyes overlap, so one eye can sometimes see behind an object when the other eye cannot. This overlap allows us to see layers in front of us. What is more, our eyes predict the future, he says. Imagine a game of catch: by the time your eyes process the sight of a ball a meter away flying toward you, it will already have passed you. We tend, then, to perceive moving objects as farther along their trajectories than they really are—a quirk that explains why so many visual illusions work the way they do, Changizi suggests.

Throughout the book, Changizi peppers his explanations with quick, fascinating visual exercises that help to drive his points home; these exercises are useful because his writing ranges from clear and engaging (and even quite funny!) to dense and somewhat abstruse at times. And although Changizi's ideas sound radical—they are—he bolsters his arguments with evidence from many disciplines, among them neuroscience, evolutionary biology, medicine and linguistics. Still, the book leaves the reader feeling skeptical: Changizi's theories are appealing and logical, and he backs them with good circumstantial evidence; however, as with any evolutionary theorizing, the ideas are also nearly impossible to prove correct—or incorrect. One thing is certain: *The Vision Revolution* will make you wonder the next time you notice someone blush, catch a ball or finish reading a magazine page.

—Melinda Wenner

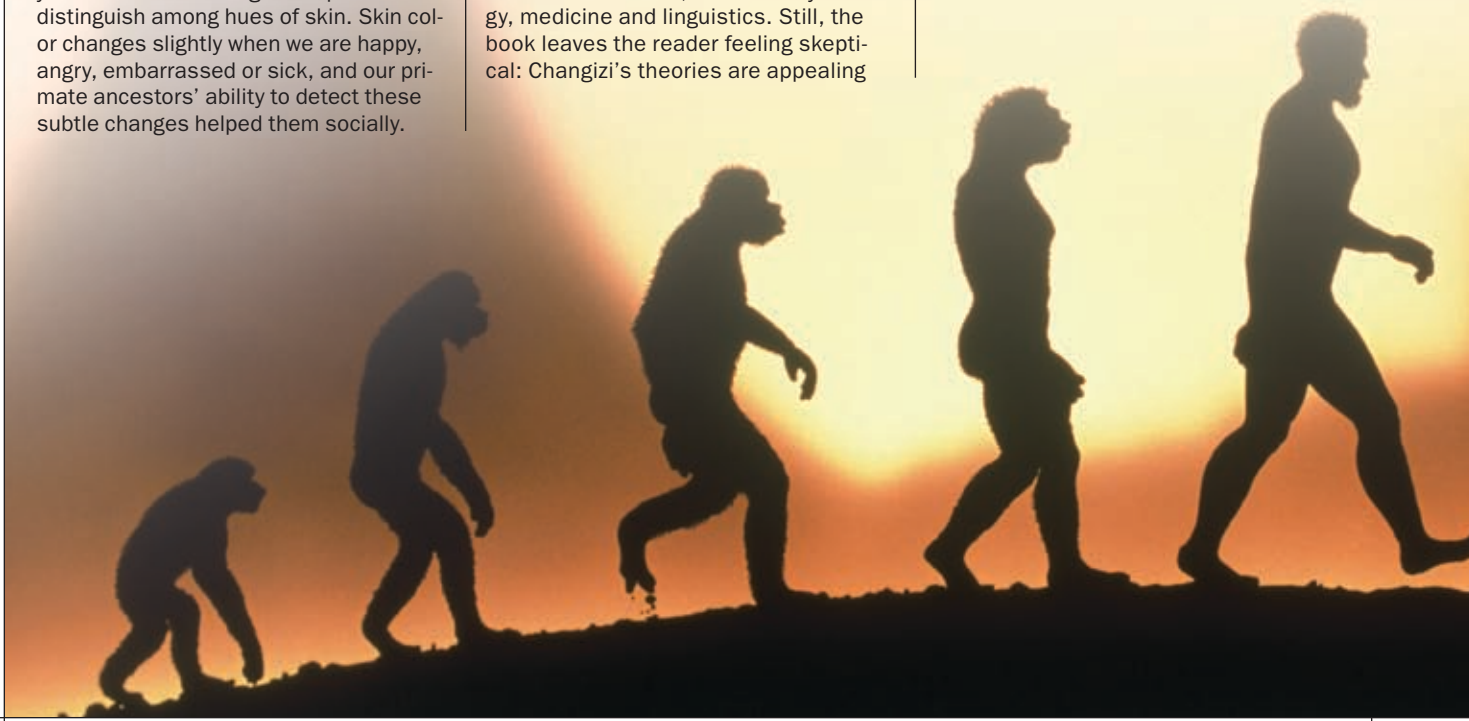


Finding Our Tongues: Mothers, Infants and the Origins of Language

by Dean Falk. Basic Books, 2009 ($26.95)

As far as we know, language is unique to humans. How and why it evolved has been debated fiercely for centuries. Now anthropologist Dean Falk presents a new theory: it was the tightening of our ancient ancestors' birth canals when they began to walk upright that ultimately triggered the development of language.

As incredible as this hypothesis sounds, *Finding Our Tongues* builds a plausible case for it. Fossil evidence shows that as prehistoric moms began to live a vertical lifestyle, the anatomical rearrangement that accompanied it turned childbirth from a more or less



IMAGESTATE age fotostock (evolution)

breezy exercise into a risky ordeal that frequently ended in death. As a result, evolution favored smaller and more immature babies, Falk says. These little newborns were too weak and tiny to cling to their mother's tummy as all other primates did. That is why mothers instead had to carry their little ones to maintain physical contact, which, much research shows, is what all babies want more than anything.

But this carrying posed a dilemma, because to gather food women had no choice but to lay their babies down. Deprived of the protection and comfort of their mother's body, babies start to fuss. That fact, according to Falk, sowed the seeds for language because to maintain contact and soothe their kids, mothers invented the precursor to language: baby talk. "These vocalizations would have been the best way to sustain mother-infant bonds," Falks says. Over millions of years the singsong babbling turned into full-fledged language, she claims.

Finding Our Tongues, though at times repetitive, ultimately provides a fresh and different perspective on language and its mysterious origins. Nevertheless, because Falk's theory—like other theories on the origins of language—is based mainly on conjecture, the jury is still out on whether it actually was our ancestors' changing anatomy that eventually compelled them to speak. *—Nicole Branan*

JOSEPH SINNOTT WNET.org (Borenstein)

Past Minds

More books on human mental history from leaders in their fields:

» Archaeologist Colin Renfrew delivers a brief, detailed history of human evolution and archaeological science in ***Prehistory: The Making of the Human Mind*** (Modern Library, 2008).

» In ***Cave Paintings and the Human Spirit: The Origin of Creativity and Belief*** (Prometheus Books, 2009), archaeologist David S. Whitley draws on evidence from archaeology and neuroscience to explain the tangled roots of art and religion.

» Boston University's Andrey Vyshedskiy brings a neuroscientist's perspective to the discussion in ***On the Origin of the Human Mind: Three Theories: Uniqueness of the Human Mind, Evolution of the Human Mind, and the Neurological Basis of Conscious Experience*** (MobileReference, 2008).

—Compiled by Robert Goodier

television

A MENTAL ILLNESS PRIMER

Healthy Minds

www.wliw.org/healthyminds

Autism, obsessive-compulsive disorder (OCD), schizophrenia—you are probably familiar with all these disorders to some extent. But sometimes it's worthwhile to review the basics, and that's where *Healthy Minds* comes in. The Long Island–based TV series offers an excellent introduction to a variety of mental illnesses and neurological disorders, featuring top researchers, such as Nobel Prize–winning neuroscientist Eric Kandel of Columbia University and child psychiatrist Judith Rapoport of the National Institute of Mental Health. The series is available online, and episodes are scheduled to air nationally on PBS stations in the fall.

Each episode focuses on a particular disorder and usually includes three stages: an overview of symptoms, a description of current treatments, and patient narratives. A chief goal of the series, hosted by psychiatrist Jeffrey Borenstein (*right*), is to help remove the stigma associated with mental illness and raise awareness of the treatments available. In the segment on OCD, radio news anchor Jeff Bell describes how he used to hide his symptoms from co-workers and loved ones. Only when he discovered Rapoport's book on childhood OCD did Bell realize that he suffered from a known disorder that could be treated. In another installment, law professor Elyn Saks gives a surprisingly plain-spoken account of how she learned to manage her schizophrenia symptoms, such as hallucinations.

The series seems to be aimed mostly at people with very little background knowledge; the producers steer clear of any research that is cutting-edge or controversial. But even knowledgeable viewers will find the patient accounts compelling, because they humanize disorders that many of us think of or know about only in the abstract. *—Erica Westly*

askthe**Brains**

Why is it that once you learn something incorrectly (say, 7 × 9 = 65), it seems you never can correct your recall?

—J. Kruger, Cherry Hill, N.J.

Cognitive psychologist **Gordon H. Bower** of Stanford University answers: IDENTIFYING, CORRECTING and averting our memory errors are part of a cognitive process called memory monitoring. Incorrect associations can be tough to change, but we can use techniques to retrain our brain.

When strong habits impede our ability to acquire a desired new habit or association, we experience a common phenomenon known as proactive interference. Wrong associations appear in common spelling errors such as "wierd" for "weird" and "neice" for "niece." Persistent mistaken connections also can cause embarrassing errors, such as calling a man's second wife by the name of his first. Interference is stronger the more previous wives you've had to deal with, and it is more difficult to overcome the stronger the habits are.

Accurate memory monitoring requires a well-functioning prefrontal cortex (PFC). Young children, who have an immature PFC, and stroke patients with extensive PFC damage make more errors as a result of memory-monitoring failures. They are more likely to confuse the source of information they recall, and they are more susceptible to accepting as true an event they only imagined.

You can overcome proactive interference by consistent (even silent) correction, especially when you space rehearsals over time. But it takes some conscious practice. We have to identify (or be told) when we have just made an error so that we can correct it immediately. Our inability to do so is typically the cause of the error's persistence.

Building on the correct information can help you learn new associations to it: add something to change how you retrieve the item from your memory. You might replace your question "Name of John's wife?" with "Name of John's *second* wife?"; or use an elaboration that contains the accurate information, such as "*We* are weird" or "My niece is *nice*"; or convert 7 × 9 into 7 × (10 – 1) = 70 – 7 = 63. As you practice the elaborated association, the simpler direct association (7 × 9 = 63) eventually replaces the earlier one, which weakens without re-

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COURTESY OF GORDON H. BOWER

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hearsals. Labeling and rehearsing the wrong association (for example, saying to yourself, "7 × 9 is not 63"), however, are distinctly counterproductive.

In the art of persuasion, does a person's sex or body type make a difference?

—Randy M. Zeitman, Lansdowne, Pa.

Social psychologist **Rosanna E. Guadagno** of the University of Alabama replies:

PEOPLE ARE MORE SWAYED by the opinions and behavior of those who are like them. Specifically, those who are akin in appearance, hobbies or behavior are relatively more persuasive to one another. For instance, a study published in 2005 in the *Journal of Consumer Psychology* examined the effect of name resemblance on persuasion. Half the participants received a request to participate in a survey from someone who had the same first name as theirs and a close-sounding last name, whereas half received the same request without the name similarity. Letters matched for name similarity recruited nearly twice the number of participants.

So, yes, all else being equal, a skinny man would usually believe another skinny man over a heavier man. Things are seldom equal, however; in our society, skinny people are considered to be more attractive, and attractive people are more persuasive. We witness examples of this effect every time we turn on the television and see good-looking actors endorsing products.

The impact of a person's sex is more complicated. Overall, men are slightly more swaying than women because we tend to perceive men to have higher credibility and expertise. Yet that is not the situation when the topic is stereotypically feminine (child care, for example).

Other factors are the relationship between persuader and target (whether they are friends, competitors or strangers) and their mode of communication (face to face versus e-mail, for example). My research indicates that when a woman is trying to influence another woman she doesn't know, a face-to-face conversation works better than e-mail because women typically get to know one another quickly in person. On the other hand, a man trying to plead his case with another man he knows but is not similar to is better off using e-mail, where the focus is on the text and not the persuader.

Finally, across all communication modes, people are usually more successful at winning over members of their own sex. I have found that both men and women are more likely to adopt a more positive attitude about tighter security on campus or taking a comprehensive exam (topics most college students find abhorrent) when the persuader—either a real person or computer-controlled virtual person—matches their gender. M

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

TONIO LOEWALD

(puzzle)

Head Games

Match wits with the Mensa puzzlers

1 RENEWAL

Start with the word OLD, and change one letter at a time to fill each blank with a different three-letter word.

OLD am I. And you may find it ____, but if you will simply ____ my years up, using a calculator as an ____, perhaps you will see my personal ____ for immortality. I can get out of ____ and have no need to be spoon ____. So even though the years are a precious ____, you, too, can change and make yourself be ____.

2 WORD STACK

Fill in the blanks below according to the definitions, which are not in the correct order. Each word differs by one letter from the words immediately above and below it. Some letters are already given to help you.

_ _ _ _ _ _
_ _ **A** _ _ _
B _ **A** _ _ _
B _ **A C** _ _
B _ **A C** _ **D**

Definitions:
lots of oranges, lots of plots, lots of fighters, tooth fixers, ready

3 DOGGONE

A farmer has four dogs: Hunter, Oscar, Minny and Eve. These dogs are quiet and bark only under special circumstances. Hunter will bark once if he sees the neighborhood fox go by. Oscar will bark after he hears exactly one dog barking. Minny always barks at midnight. Eve will bark after she hears exactly two dogs barking at the same time (not sequentially).

a) On a typical night when the fox doesn't show up, how many barks should the farmer hear?

b) If the fox shows up early, around 11 P.M., how many barks should the farmer hear?

c) If the fox shows up late, around 1 A.M., how many barks should the farmer hear?

d) If the fox shows up exactly at midnight, how many barks should the farmer hear?

4 RHYME TIME

Find three rhyming words, each preceded by "a," that describe the clue words. For example:

HORN **CONCORD** **MASKING**

The answer is: a cape, a grape and a tape. What are the three rhyming words that describe each of the following trios?

C-NOTE	**BUNKER**	**LIVING**
PEACH	**TRIPLE**	**EARTHA**
KITCHEN	**CHANEL**	**HEIDI**
BEARER	**DUCK**	**MARILYN MONROE**
FIFTY-NINE	**BURGLARY**	**KEY**

5 WORD MAZE

Find your way through the word maze. Go from word to word by matching identical letters in identical positions. For example, you can go from PIG to MICE because they both have the letter "I" as the second letter. But you cannot go from ICE to MICE, because although they have many letters in common, none of them are in the same position. Start at the word IN, and see if you can get to OUT.

IN TRY SMALL EXIT GET FAD HYPE AND TO SIGNS EVER HINTING ILL BAD GLOOM AROUND HYPE FOLLOW PHOBIA NEAR OUT

6 SENTENCING

What is unusual about the following sentence?

I am the news today—merely noticed, socially withdrawn, devastated.

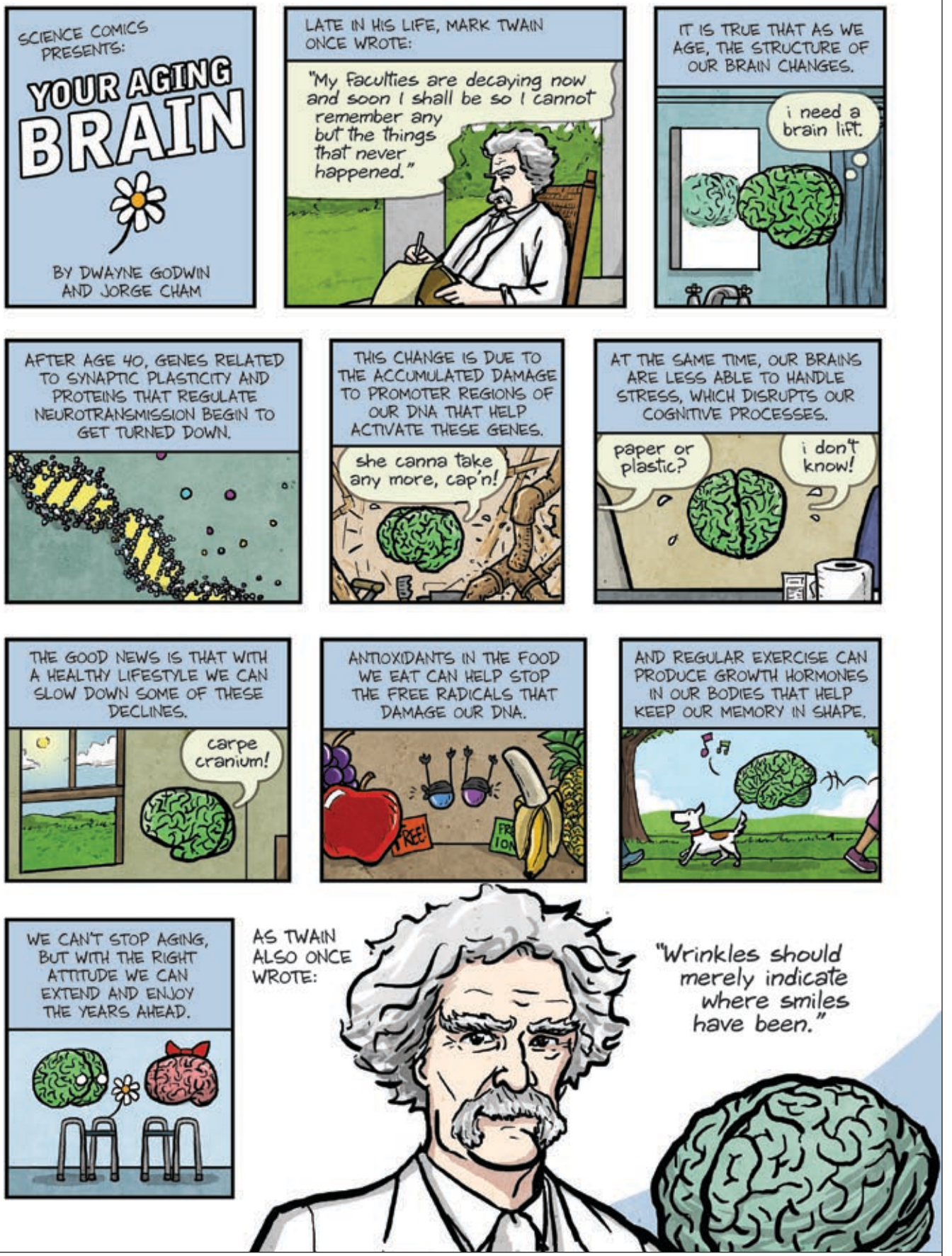
7 SENTENCING II

What is unusual about the following sentence?

He expected determined dealing—greedier robbing greedy—yet the extravagant trappings, signaling great treasures, sent this surprising greeting: "Good deal!"

Answers

1. OLD, ODD, ADD, AID, BID, BED, FED, FEW, NEW
2. GROVES, GRAVES, BRAVES, BRACES, BRACED
3. a) Two barks (Minny, then Oscar).
   b) Four barks (Hunter, then Oscar; Minny, then Oscar).
   c) Four barks (Minny, then Oscar; Hunter, then Oscar).
   d) Four barks (both Hunter and Minny bark, then Eve, then Oscar).
4. A ill, a hill and a will.
   A pit, a hit and a Kitt.
   A room, a perfume and a Klum.
   A bond, a pond and a blonde.
   A prime, a crime and a lime.
5. There is more than one way to get through the maze. Here is our favorite: in and around try to follow small signs hinting exit ever near get out.
6. Each word increases in length by one letter.
7. The last letter in a word is the first letter of the next.



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