

SCIENTIFIC AMERICAN  
**MIND**

BEHAVIOR • BRAIN SCIENCE • INSIGHTS

March/April 2011

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**GREAT PRETENDERS?**  
Plagued by Self-Doubt



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BEHAVIOR • BRAIN SCIENCE • INSIGHTS

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## Dream Weavers

For as long as I can remember, I have lived in two worlds. One is the environment that I physically occupy. In that reality, I am a wife and mom who lives in the suburbs and has a really interesting editorial job. But in my inner world, things change fluidly. When I was a shy little girl, for instance, I imagined I was bold and outgoing; I could tell great jokes, and everybody would laugh. Sometimes I would conjure a new place—even outer space. Why not? In my secret world, I could go anywhere I pleased and be anything I wanted to be.

I had no idea, until much later, that not everybody has such elaborate fantasies—or that they could be problematic for some people who get too engrossed. Still, as Josie Glausiusz writes in this issue’s cover story, “Living in a Dream World,” people generally spend about 30 percent of their days with their minds elsewhere. Daydreaming can inspire us and help us be more creative. But like an overdose of honey, it can also be cloying or smother us if we overindulge. Turn to page 24 to learn more.

Apart from our waking visions, our internal perceptions can trap us into not accepting reality. One such case is people who experience the “imposter phenomenon.” As Birgit Spinath writes in “Great Pretenders,” starting on page 32, such individuals believe their achievements are actually undeserved. Although all of us tend to grant a measure of power to external factors over our successes and failures, victims of imposter thinking go much further. They are in constant fear of being found out as swindlers.

Daydreaming and imposter thinking are hidden shades of our personalities. But what about how we look to the world? “You Are What You Like,” proclaims Christiane Gelitz in her article beginning on page 38. We reveal a lot about ourselves by our cultural preferences: by our music choices, our art tastes and even how we decorate our surroundings. As opaque as we sometimes perceive ourselves to be to others, we are often endearingly transparent as a species.

Mariette DiChristina  
Editor in Chief  
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COVER PHOTOILLUSTRATION BY AARON GOODMAN

COVER STORY

24» **Living in a Dream World**

Daydreaming can help solve problems, trigger creativity, and inspire great works of art and science. When it becomes compulsive, however, the consequences can be dire.

BY JOSIE GLAUSIUSZ



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People who experience the “impostor phenomenon” believe their successes are undeserved—and they live in constant fear of being unmasked.

BY BIRGIT SPINATH

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The Beatles or Brahms, Bauhaus or Braque—your cultural preferences say a lot about your personality.

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Teaching a machine to speak has been a dream for decades. First we have to figure out how we know what we know about language.

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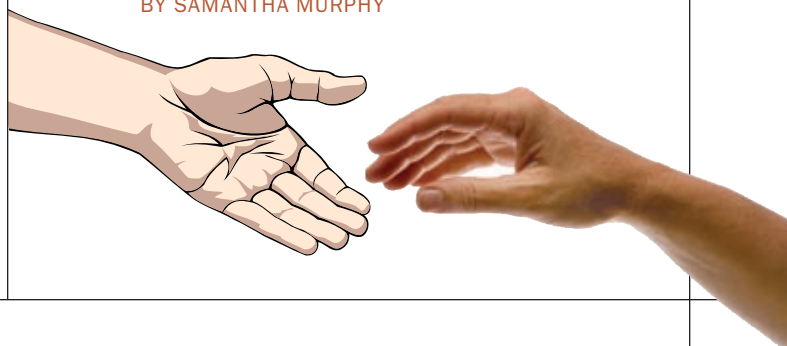
Many common ailments and physical conditions can influence the brain, leaving you depressed, anxious or slow-witted.

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BY SAMANTHA MURPHY





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7. Coming to Your Senses
8. Perception and Your Brain's Little Lies
9. Pain—All in Your Head?
10. Decisions—Your Brain's Secret Ballot
11. Reward, Adaptation, and Addiction
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14. Learning, Studying, and Sleep
15. Willpower and Mental Work
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17. Biological Timekeepers and Jet Lag
18. The Hidden Talents of Infants
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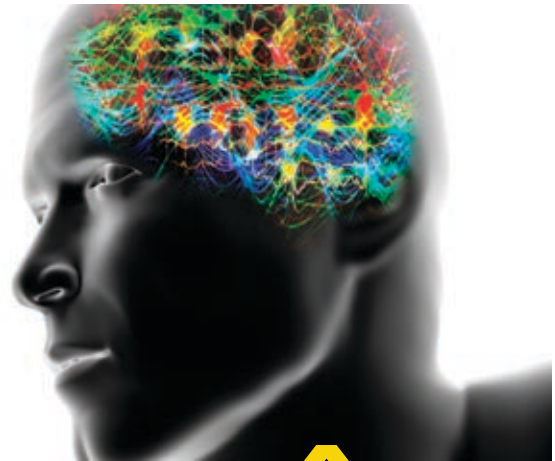
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Updated on Bright Horizons 9, you'll bring a breath of rational fresh air to discussions of evolution, the paranormal, and urban legends. Make waves with a look at gender and the brain. Examine how virtual reality impacts face-to-face life. Satisfy your curiosity about the persistent appeal of extra dimensions. Fill in the blanks in Colonial American archaeology and cultural anthropology with a discerning look at Florida and the southeastern United States.

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

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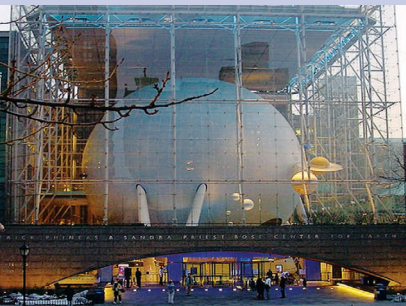
**Saturday, May 7, 2011** (optional)

Wake up in the city that never sleeps, as we start at 9am in the Rose Center for Earth and Space (below) at the American Museum of Natural History for a private insiders' tour. During our tour we'll get the inside scoop on research being done at the Rose Center. After our astronomy sojourn, we'll reconvene in lower mid-town Manhattan, at the Scientific American headquarters, for an early evening social reception/dinner with Scientific American staffers.

*During our visit, the Curator of the Einstein exhibit, and our day's host, Dr. Michael M. Shara will deliver the following two lectures:*

**Einstein's Revolution**—He was daring, wildly ingenious, passionately curious. He saw a beam of light and imagined riding it; he looked up at the sky and envisioned that space-time was curved. Albert Einstein reinterpreted the inner workings of nature, the very essence of light, time, energy, and gravity. His insights fundamentally changed the way we look at the universe.

**10 Discoveries from the Hubble Space Telescope**—In the 20 years it has been in orbit, Hubble has revolutionized our understanding of how the universe works. Images from the telescope have become iconic forms of modern art. And lurking in each image is new science. Dr. Shara will describe 10 remarkable discoveries made with the Hubble, and show how its images reveal something we've never seen or understood before.



### VIRTUAL WORLDS

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

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

### BRAIN DIMENSIONS

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

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

### RATIONAL THOUGHT — AND NOT

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

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



### UNIVERSAL QUESTIONS

Speaker: **Max Tegmark, Ph.D.**

- The Mysterious Universe
- The Inflating Universe
- The Mathematical Universe

### ARCHAEOLOGY/ANTHROPOLOGY

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

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

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### MAKING MAGIC MUNDANE

**Your article** in the November/December issue on how habits of perception and brain functioning are essential for so much of the success of magic tricks ["Mind over Magic?" by Stephen L. Macknik and Susana Martinez-Conde, with Sandra Blakeslee] was fascinating to me. It reminded me of an interesting observation about magic I accidentally made back in the 1970s.

I was watching a television special by magician Doug Henning. Normally I'm the perfect audience for magic tricks; I go with the flow and gasp in amazement. But this time, after half an hour, I turned off the TV, bored, because I saw a probable opening for each illusion.

Why the change? I was tired, and so I was lying on my side to watch the show, with my head horizontal instead of vertical. I realized that our habits of perceptual construction are almost always learned and reinforced while we are in an upright position. Somehow lying down did not provide the implicit body cues associated with all those learned expectations, so my attention was not led in the normal way.

I have tried it a few times since, and I do not recommend it if you want to enjoy magic shows!

**Charles T. Tart**  
Palo Alto, Calif.

### TALK THERAPY'S COUSINS

**I applaud** Jonathan Shedler's emphasis on the tremendous value of psychodynamic therapy in your November/December issue's "Getting to Know Me."

I have been a psychiatrist and psychoanalyst for more than three decades, and I have seen many people greatly helped by this method of treatment.

But I also have seen many people helped immensely by psychoanalysis, which is by no means a method of treatment only of "yesteryear." Many young therapists are still studying and practicing psychoanalysis as well as psychodynamic psychotherapy. Many hundreds of analysts have added to Freud's pioneering ideas over the past century.

Yet I must reiterate that I am grateful that your article was so positive about the reality and value of psychodynamic psychotherapy.

**Landrum S. Tucker, Jr.**  
Psychoanalytic Institute  
of the Carolinas  
Chapel Hill, N.C.

**I initially welcomed** the article on psychodynamic therapy in the last issue. It started with gusto and provided a succinct and informative overview of its key principles and techniques and the most recent evidence for its efficacy.

Regrettably, however, the article was compromised by an ongoing comparison to a description of cognitive-behavior therapy (CBT) that was ill informed and inaccurate. CBT does not "seek to persuade" patients, nor is it focused on "mental illness" but on people seeking help for distress.

Contrary to the impressions in Shedler's article, CBT is based around a collaborative relationship between the therapist and client, who develop a shared understanding of the links between thoughts, feelings, behaviors, other people, and the unconscious rules and assumptions of the client. CBT therapists are consistently rated as having the strongest therapeutic alliances with their clients compared with other therapists.

The article gave the impression that psychodynamic therapy has a larger effect



size than CBT from “one major study” that is not referenced. This is not a fair reflection of the literature. Differences between the effectiveness of different therapies are rarely identified, but still, a range of reviews points to the advantages of CBT over psychodynamic therapy.

Psychodynamic therapy has its own scientific foundations and appeal and therefore should not have to rely on an argument against a straw man in the form of a caricature of CBT nor on a selective review of the literature to make its case as a viable contemporary therapy. This only serves to isolate the field further and miss the opportunity to provide a shared vision of psychotherapy that could truly benefit a wide range of people.

**Warren Mansell**

Cognitive-behavior therapist and  
clinical psychologist  
University of Manchester, U.K.



**Do religious and spiritual activities help kids grow up healthy and happy?**

#### PARENTING CONCERNS

**When I began reading** “What Makes a Good Parent?” by Robert Epstein, I expected to find an intelligent discussion of high-quality research into an incredibly important topic. Instead I encountered an article littered with underqualified claims.

First, the study relies solely on convenience sampling and self-reporting, which is much less rigorous than many

studies in this area. Even more disturbing was the lack of effort to qualify the findings in light of the methodological limitations. For instance, the outcome variable of children’s happiness should be referred to as “parents’ perceptions of children’s happiness” because of the lack of verification of happiness with the children themselves.

In light of these flaws, I found it was, at the least, inappropriate and, at the most, dangerous, to report the results with such authority. This article was certainly not up to the high standards for inclusion I have come to expect from *Scientific American Mind*.

**Regan Clark Foust**  
via e-mail

**I found** “What Makes a Good Parent?” very alarming! Epstein writes in his top-10 list of good parenting that number nine is religion, without citing any real scientific data to back it up. I was appalled by this assertion because religion is directly undermining science education and acceptance in America today. I have to question the author’s motives—he seems to be projecting his own belief system into this article.

**Bridget Anderson**  
Portland, Ore.

**EPSTEIN RESPONDS:** *Some of the experts who evaluated the parenting test when we were developing it also objected to our inclusion of the “religion and spirituality” category. We had to include it, however, because legitimate studies exist that show that children who are raised in an environment of religion or spirituality flourish in various ways. Bear in mind that it is not necessary for an individual to be adept in all 10 areas to be a good parent overall.*

#### THIS DREAM SMELLS

**Will someone** please let Christof Koch know that some of us can and do smell in our dreams?

The very night after I

read his article, “Dream States” [Consciousness Redux], I dreamed I was escaping from pursuers through an unfamiliar house of cramped rooms. Passing through a door, I found myself looking down into a pair of green-and-white tiled bathrooms with wooden floors, two white toilets, and an unpleasant smell of, well, excrement.

When I woke in the middle of the night, I could distinctly remember the bathroom and the smell, and I could do so still well into the next day.

**Bob Wolfson**  
Marietta, Ga.

#### IN DEFENSE OF “AUTISTIC”

**Reader** Greg O’Brien [“People with Autism,” Letters] needs to calm down a bit.

To assert that a term such as “autistic toddlers” is disrespectful is the height of absurdity. This is a simple description, perfectly valid in the English language: adjective, noun. Is it similarly disrespectful to refer to “tall children?” Must we refer to them as “children with tallness?” Let’s contact the DAV (Disabled American Veterans) to let them know that they are disrespecting themselves. They should change the name of their organization to “American Veterans with Disabilities.” Oh, wait. We can’t refer to them as “American Veterans.” No, it would have to be “Veterans Who Are American and Have Disabilities.” Yes, that sounds much more respectful.

Your magazine is great, and your editing is fine. Don’t kowtow to the PC police!

**Jonathan Lavi**  
New York City

**ERRATUM** “More Vitamin D Could Prevent Some Psychosis,” by JR Minkel [Head Lines], incorrectly stated that the molecule 25OHD is converted in the body to vitamin D. The correct relation

is the reverse: vitamin D is produced in the skin and metabolized in the liver into 25OHD. Thanks to reader Gary L. Lensmeyer, a vitamin D researcher, for pointing out the error.

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>> ABSTRACT THINKING

## Which Way Is the Future?

How we imagine the movement of time depends on what language we speak

If you had four pictures of a person at different ages, how would you lay them out in chronological order? As an English speaker, you would almost certainly put childhood scenes on the left and pictures from old age on the right. But if you spoke another language, you might arrange the photos in a column or even from east to west.

Almost every culture in the world uses space to think about time, but the visualizations vary widely. A November paper in *Psychological Science* describes the first culture known to tie time's march to the cardinal directions.

The Pompuraawan, a remote tribe in Australia, do not have terms for spatial relationships such as "left" or "in front of." Instead they use the directions as descriptors, such as "my south arm." They think of time the same way, the new study found. When asked to arrange four pictures showing a person's life, Pompuraawans laid the photos in a line from east to west.

Three main factors affect how people imagine time, says Stanford University psychologist Lera Boroditsky, an author of the study. One influence is how the culture thinks spatially; for instance, the Pompuraawans often gesture to the sun to indicate the time of day, Boroditsky says.

The layout of the written word also plays a role. Israelis tend to think of time as flowing from right to left, Boroditsky concluded in a study last year—the same direction Hebrew is written.

Last, a language's metaphors can have an effect. Mandarin Chinese associates "up" with the past and "down" with the future. And research shows Mandarin speakers often put photos in a column with the earliest at the top.

Visualizing the passage of time may be a human universal, but these studies show just how differently that can play out. Whereas we look forward to the future, the Pompuraawans say that the west is yet to come. —Valerie Ross

>> MIND-BODY CONNECTION

## When Photos Are Painkillers

Looking at a picture of a loved one can dull physical pain



Many mothers offer their young children a hand to squeeze as they brave a vaccination in the doctor's office. We instinctively know that contact with a loved one can help mitigate pain—and the scientific evidence concurs. Now two recent studies show that a mere reminder of an absent beloved—a photograph—can deliver the same relief.

A *Psychological Science* study in 2009 first showed the effect. Psychologist Sarah Master of the University California, Los Angeles, and her colleagues studied 25 women and their boyfriends of more than six months. The researchers subjected the women to different degrees of thermal stimulation—a sharp, prickling sensation—as they either held their boyfriend's hand while he sat behind a curtain, held the hand of a male stranger behind a curtain, viewed a photograph of their boyfriend or viewed a photograph of a male stranger. Holding their partner's hand or viewing his photo decreased the women's pain significantly more than touching or viewing a stranger—and the photo was just as effective as the physical contact.

A more recent study in the October issue of *PLoS One* peered inside the brain to better understand how love soothes pain. Neuroscientist Jarred Younger of Stanford University and his colleagues recruited 15 students who were in the first nine months of a new and passionate relationship. While lying inside a functional MRI machine, the participants focused on photographs of their partners or on pictures of similarly attractive acquaintances, or they played a word association game. During these distractions, the experimenters applied mild, medium or painful temperatures to the students' palms. Images of attractive acquaintances were not very effective painkillers, but gazing at the faces of significant others and playing the word game reduced reported pain on average between 36 and 44 percent and high pain between 12 and 13 percent.

Only photos of loved ones, however, sparked activity in reward centers within the amygdala, hypothalamus and medial orbitofrontal cortex. The faces of romantic partners also decreased activity in major pain-processing areas, such as the left and right posterior insula. Because the reward centers did not flutter in response to the distracting word game, the researchers argue that the salve of romantic affection is not mere distraction—it is a bliss as potent as that of drugs such as cocaine, which invigorate the same pleasure pathways.

A photograph may not need to show a significant other to produce analgesic effects—any loved one could do, thinks neuroscientist Lucy Brown of the Albert Einstein College of Medicine of Yeshiva University, who was not involved with the study. “Whether a photo of a boyfriend or girlfriend works better than one of your spouse, child or beloved pet, I'm not so sure,” she says. So the next time you have to squeeze into a cramped airplane seat or trudge to work with a bad cold, consider bringing a picture of someone you love to make things more bearable. —Ferris Jabr



>> BELIEFS

## Drowning Out Doubt

When we feel uncertain, we work harder to win others over

People preaching their point of view seem awfully sure of themselves. But we often try hardest to persuade when our confidence has been shaken, suggests an October study online in *Psychological Science*. In the experiment, volunteers wrote essays aimed at strangers about their views on animal testing or dietary preference. When the subjects' confidence was first challenged by recalling experiences that made them feel uncertain or having to write with their nondominant hand, they wrote longer essays. Because we define ourselves largely by our beliefs, the researchers say, we try to shore up our self-confidence by convincing others to see it our way. Supporting this idea was the finding that when the volunteers were given a different opportunity to reaffirm their attitudes before writing their essays, such as making a list of their music and movie preferences, the effect disappeared. —Valerie Ross

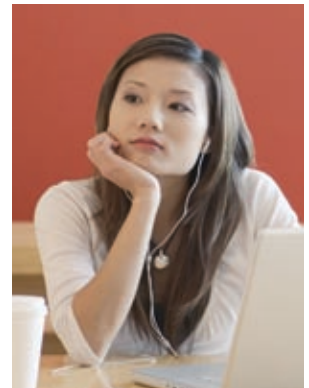
GETTY IMAGES (left); IMAGE.COM/CORBIS (right)

>> ATTENTION

## Lose Focus, Lose Happiness

A wandering mind may bring you down

Daydreaming may boost creativity, but a new study from psychologists at Harvard University suggests that letting your mind wander may also lead to unhappiness. The researchers had more than 2,000 study participants use an iPhone application that randomly asked them to report their current activity and state of mind. The results indicate that people's minds wander an awful lot: of the 22 activities subjects could choose from, sex was the only one not associated with distraction. Minds were wandering at least 30 percent of the time during everything else from work to conversation—and the more people reported being distracted, the lower they reported their mood. There may be something to “living in the moment” after all. —Erica Westly



AGE FOTOSTOCK

## >> MATERNITY

### A New Mom's Changing Brain

Certain areas grow bigger as a mother bonds with her infant

A new mother's body goes through many changes—among them, key parts of her brain get bigger, according to research reported in October's *Behavioral Neuroscience*. And the more these areas grow, the greater the mother-infant bond seems to be.

Structural changes in animal brains, says National Institutes of Health neuroscientist Pilyoung Kim, are critical to getting mothers to take care of their offspring. Similar changes in human mothers, she observes, might be necessary for attentive parenting and ultimately forming long-term emotional bonds, and now there is evidence suggesting that possibility. Using MRI, Kim and her colleagues at Yale University and the University of



Michigan at Ann Arbor produced detailed maps of the brains of 19 new mothers a few weeks after they gave birth. At around the same time, the researchers asked mothers to select words from a list of positive descriptors such as “beautiful,” “perfect” and “special” to describe how they felt about their babies and

about their experience of parenting.

When the scientists mapped the mothers' brains again about three months later, some areas had grown, including the hypothalamus, amygdala and substantia nigra—regions that animal studies suggest are involved with caring for, learning about and forming positive feelings toward newborns. The planning and decision-making part of the brain, the prefrontal cortex, also grew. In addition, mothers who initially chose more of the positive words to describe their feelings about their babies showed more brain growth. The investigators do not yet know what causes what—if brain growth leads to more positive feelings, or vice versa—but the results indicate for the first time a connection between mothers' subjective feelings and physical changes in the brain. Kim says they are planning more studies to investigate the phenomenon, including one that will look for similar changes in fathers. —Nathan Collins

## >> PSYCHIATRY

### Hyper One Day, Calm the Next

A diagnosis of ADHD may vanish over time

Attention deficit hyperactivity disorder (ADHD) is a chronic condition, and if left untreated, it can set a child up for a lifetime of difficulties in learning and forming relationships. At least that is the assumption that has guided the popular approach to treating ADHD for decades. But new research suggests that ADHD might be much less persistent than previously thought.

A team led by Prudence Fisher and J. Blake Turner, both at Columbia University and the New York State Psychiatric Institute, reviewed the records of nearly 1,500 children from four studies that had used a standard diagnostic interview to screen for ADHD. They found that a majority of children who qualified for an initial diagnosis had lost their diagnosis by two years later.

ADHD has three subtypes: hyperactive, inattentive and both combined. More than half the children with the hyperactive and inattentive subtypes of the disorder had reverted to no ADHD at a two-year follow-up interview. Although the combined subtype was more persistent, between 18 and 35 percent of children in that group had also lost their diagnosis by the follow-up. Kids with many symptoms and significant impairment were just as likely to



lose their diagnoses as children with milder forms of the disorder. Nor were the losses attributed to successful treatment.

To Turner, the findings suggest that the current definition of ADHD would benefit from greater specificity. If a disorder is, by definition, long-lasting, “then we are over-diagnosing ADHD,” Turner says. He and Fisher are advisers to the ongoing revision of the *Diagnostic and Statistical Manual of Mental*

*Disorders (DSM)*, the handbook of guidelines for diagnosing psychiatric disorders. Turner recommends a cautious approach to labeling and medicating kids whose behaviors, though irritating to many adults, are likely to be transient.

Joel Nigg, a professor of psychiatry at the Oregon Health and Science University who was not involved with the study, says that the finding reflects our evolving understanding of ADHD. Fifty years ago experts believed that most children “grew out of it.” In the 1970s and 1980s new studies appeared to show that ADHD is lifelong. The truth might lie somewhere in between. “The corrective here,” Nigg says, “may be that it's chronic sometimes, a fluctuating condition in other cases, and it may be that some kids get better.”

—Katherine Sharpe

>> GENDER

## Marijuana and Maleness

Chemicals in cannabis encourage masculine behavior in young rats

The sex hormones that bathe a fetus in the womb are some of the earliest and most potent determinates of gender differences in brain structure and social behavior. But other chemicals produced by the human body more subtly tweak the neural pathways underlying these distinctions. Endocannabinoids, natural compounds in the brain that excite the same receptors as marijuana, influence gender-specific behaviors, according to a study published in November in the *Proceedings of the National Academy of Sciences USA*.

Desiree Krebs-Kraft of the University of Maryland School of Medicine, Baltimore, counted the number of actively dividing glia (nonneuron brain cells) in the medial amygdala (MeA) of four-day-old rats. The MeA controls gender-specific differences in youthful play and regulates mating, parenting, aggression and territoriality in adults.

Krebs-Kraft found that females had more dividing MeA glia than males did. But when the researchers gave newborn rats a drug that mimics the effect of endocannabinoids on brain cells, the rate of cell division in females slowed to the same pace observed in male brains. The drug also changed behavior. Juvenile male rats usually engage in more social play than females, but female rats that received the drug frolicked just as much as the males.

Marijuana affects the mind because substances in the plant called cannabinoids imitate the naturally occurring endocannabinoids found in the brain. "Our results show that endocannabinoids are part of a natural signaling system that underlies the establishment of sex differences in the brain that are an important part of social behavior," explains



Margaret McCarthy, one of the study's co-authors. "This would suggest that the use of cannabis during pregnancy could alter those systems and have unintended consequences," she says, though cautioning that much more research is needed to say for sure. Studies have shown that the cannabinoids in marijuana can in fact breach the placenta, so an indulgent mother is smoking for two.

Curiously, the cannabinoid treatment had no effect on cell division or play behavior in males. The researchers found that male rats have inherently higher levels of endocannabinoids in their brains than females, so trying to give the males a little boost did not cause any measurable changes.

—R. Douglas Fields

>> CREATIVITY

## Two Narcissists Are Better Than One (or Three)

Self-obsessed individuals are not more creative in general, but they may impress when competing with a like mind

For many years psychologists have explored whether narcissism and creativity are linked, and some studies have suggested that the self-obsessed may, in fact, be more creative than the rest of us. But new research from Cornell University argues otherwise.

Two hundred and forty-four undergraduates completed a test that measures narcissism (with questions such as, "I enjoy being the center of attention"). Participants then paired up and "pitched" movie ideas to one another, with one playing the role of pitcher and the other evaluator. Narcissistic participants' pitches were

consistently rated as especially creative by evaluators, but when independent evaluators—unaware of which participants were self-obsessed—reviewed transcripts of the pitches, the narcissists' pitches were not rated as more creative. This result suggests that charisma influences how egotists' ideas are received, but the ideas themselves are no more creative than average.

Researchers then paired 292 undergrads (all of whom completed the narcissism test) into 73 four-person groups. The groups were given the task of proposing creative ways for a



company to improve its performance. The experimenters found that having two narcissists in a group produced more creative results than a group with none, because their competitiveness sparked more brainstorming. But when more than two narcissists were in a group, the opposite happened—hyper-competitiveness scuttled the group's productivity.

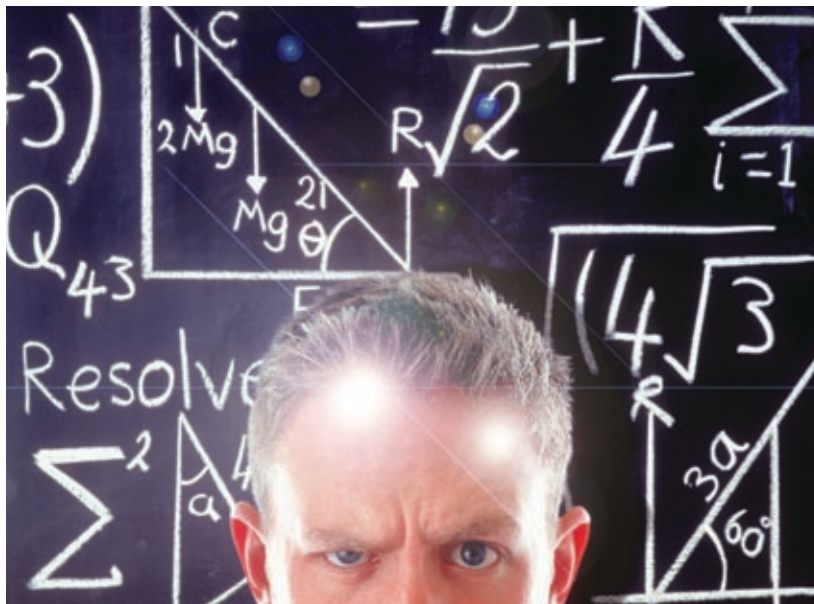
—David DiSalvo

## (head lines)

### >> NUMERACY

## A Stimulating Solution for Math Problems

A device that sends electric current through the brain improves numerical skills



People who struggle with basic arithmetic may get a boost from a tool that electrically stimulates the brain, according to a study that appeared November 23 in *Current Biology*.

Researchers at the University of Oxford and University College London studied people with normal math skills using a noninvasive technique called transcranial direct-current stimulation, in which scalp electrodes emit current that modulates neural activity. The team focused on the right parietal cortex because it contributes to spatial and mathematical thinking. This brain region shows abnormal responses in children with developmental dyscalculia, a learning disability that affects math skills.

with matched trials, just as adults are when they respond to real digits. But participants who did not receive the same pattern of stimulation showed no difference between these trials, suggesting they had not internalized the symbols' meaning. The results indicate that right-hemisphere stimulation helps people learn numerical symbols.

The superior performance lasted for six months—a long effect that suggests the method may someday benefit those with developmental dyscalculia, says study co-author Roi Cohen Kadosh, a cognitive neuroscientist at Oxford. "This was the first step in finding a way to improve numerical abilities," he says.

—Janelle Weaver

### >> STEREOTYPES

## Accent Trumps Appearance

The brain pays more attention to language when we gauge someone's background

Accent matters more than looks when it comes to identifying a person's ethnicity, according to a study published in the November *Journal of Personality and Social Psychology*. Researchers at Friedrich Schiller University of Jena in Germany asked students to identify Italian- and German-looking men who spoke German with or without an Italian accent. The students were more likely to confuse two people who spoke with the same accent than two who looked liked they belonged to the same ethnic group, meaning accent was more of a distinguishing feature than appearance. The authors say their results emphasize the importance of language in how we judge those whom we meet.

—Nathan Collins



HUGH SITTON Corbis (top); CORBIS (bottom)

>> IDENTITY

## Embracing the Radical

When in doubt, people shift toward extreme points of view

Feeling uncertain about who you are and what you want to do with your life? Such doubt may lead you to sympathize with a radical or extremist group, according to a new study in the *Journal of Experimental Social Psychology*. Groups that rally around radical beliefs may provide a searching person with the sense of self and social identity they are lacking.

Michael Hogg, a psychologist at Claremont Graduate University, and his colleagues increased feelings of doubt in a group of college students by asking them to write down several things about which they felt uncertain. The researchers then asked them whether they supported some very strong (some might say radical) responses to tuition increases, such as blockading the campus, rallies and vigorous protests. The experimenters found

that these uncertain students stopped preferring the usual moderate courses, such as holding meetings, printing leaflets and sending letters to newspapers, and they shifted toward favoring the more radical actions.

The results hint that organizations espousing extreme views may be especially attractive to people with questions about their purpose. "Some groups provide a more clearly defined sense of self," Hogg explains. "These are the groups that seem from the outside to be a bit cliquish, a bit closed. At the extreme, you get groups that look like religious terrorist groups." Helping people navigate through times of social change, therefore, by providing them with a strong sense of self and belonging, may help lower the risk that they will end up in extremist organizations. —Carrie Arnold



>> PERCEPTION

## She Moves in Mysterious Ways

What happens in the brain when we see someone in a posture we cannot imitate?

Whether we are watching Kobe Bryant sink a pull-up fadeaway jumper or Mikhail Baryshnikov perform a grand jeté, there is no denying our awe of people who can move in ways we cannot. Researchers recently identified the brain regions that become active when we see extraordinary postures, offering insight into how skilled athletes and performers confound us.

Previous research has shown that a network of mirror neurons in the brain is activated when we watch people move in familiar ways—we mentally rehearse their actions as if we were performing them ourselves. But what happens when we observe people moving in ways we cannot? Emily Cross and her colleagues at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig scanned the brains of 18 people with functional MRI while showing them photographs of a contortionist in ordinary positions—stretching to one side, for example—and in contorted postures such as lying on her stomach with her toes touching her forehead. Whether the participants saw contorted or ordinary postures, the mirror neuron system



became activated. But another region of the brain that responds strongly to seeing the human body and limbs—the extrastriate body area (EBA)—was even more active when a person saw contorted postures.

"The fact that the mirror neuron system doesn't discriminate means it's not as simple as we thought," Cross says, in reference to the theory that these cells "mirror" others' actions exactly. "When we start seeing bodies that are doing different postures, it seems to be the visual regions pulling apart what we can and can't do." She notes that this study looked at only static body postures, but together with subsequent experiments—including one in which people watched videos of gymnasts—it offers a possible mechanism for how the brain predicts what will happen a few seconds ahead of what we experience.

It could be that when we watch someone dance or run down a basketball court, our brain is imagining us doing the same action until the dancer pirouettes or the player slam-dunks. At that point the brain engages the visual EBA region to make sense of what we are seeing. —Alison Snyder

## (head lines)

### >> DEVELOPMENT

## Blissfully Unaware

Kids may lack self-consciousness because a key network in their brain is not yet synchronized

If two men began a boisterous tug-of-war over the wine list at a posh restaurant, more than a few heads would turn. Yet two six-year-old kids quarreling over a pack of crayons at a diner would hardly seem unusual. It is normal for kindergartners to act out and for grown-ups to show restraint. But social pressure alone cannot explain why adults are so

network is not fully coordinated until around the age of 13.

Neuroscientist Stuart Washington of Georgetown University Medical Center asked 42 participants aged six to 27 to stay inside a functional MRI scanner and play a simple game, searching groups of arrows for one pointing in a different direction from the rest. But the researchers were not interested in brain activity during the active task—they wanted to observe the brain during periods of rest between tasks. In the past decade scientists have discovered that a particular network of brain regions consistently stirs to life whenever people are at wakeful rest inside fMRI machines, not focusing on anything in particular. Studies have tied this default network to daydreaming [see “Living in a Dream World,” on page 24], introspection, moral reasoning, thinking of the future and the ability to see the world through others’ eyes.

When Washington compared the activity of the default network in people of different ages, he found a clear pattern. The older the participant, the more synchronized the interaction of the default network’s five primary nodes, which are spread throughout the brain. Children aged six to nine showed hardly any synchronized communication in the default network. But by 13 years of age, the participants began to demonstrate neural coordination typical of an adult.

“Our results imply that children are less able than teens and adults to comprehend the consequences of their actions, think about future events or realistically

gauge how other people view their actions,” Washington explains. “Since these behavioral attributes are not fully formed in children, they are more likely to make rash decisions that do not account for consequences or other people’s perceptions.” So the next time you are stuck in earshot of squabbling youngsters, try to pardon their lack of consideration. They probably have not yet been able to imagine themselves as others see them. —Ferris Jabr



much better at thinking before they act and recognizing how others view them.

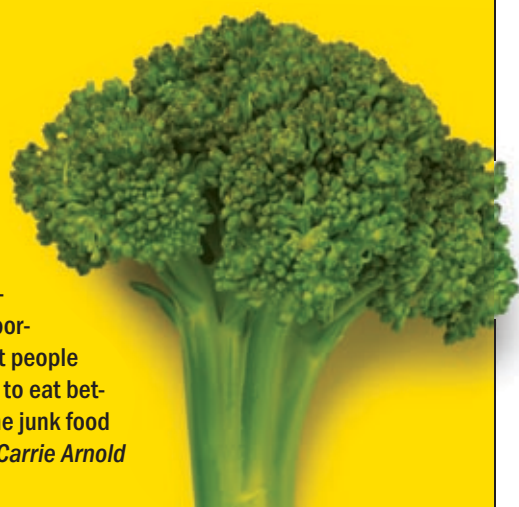
According to a new study, the development of social awareness and the introspection it requires may be linked to the development of the default network, a group of regions in the brain that are active when our mind is wandering instead of focused. The research, presented in November at the annual meeting of the Society for Neuroscience, suggests this

### >> PSYCHOLOGY OF FOOD

## My, What a Big Salad You Have

When people see health food as larger, they are more likely to want to eat it

Dieters are engaged in a constant battle between losing weight and eating tasty food. Now a study in the *Journal of Experimental Social Psychology* suggests that buttering up the brain with images of health food may help people see these items as more tempting. Researchers at Utrecht University in the Netherlands prompted unsuccessful dieters with pictures of healthy foods, then found that, later, subjects viewed portions of these foods as bigger than they actually were. Previous research suggests that people are more likely to choose foods perceived as “bigger” at mealtimes. So if you’re trying to eat better, try flipping through the veggie chapter in a cookbook rather than sitting through the junk food ads on TV—seeing pictures of nutritious items could influence your choices. —Carrie Arnold



AGE FOTOSTOCK (top); ISTOCKPHOTO (bottom)



## With the Changing of the Seasons

Higher levels of dopamine in fall and winter could explain yearly mood cycles



Winter blues, spring fever—most of us take seasonal changes in mood for granted. According to a new study, the cause might be the seasons tinkering with the chemicals in our brain. As reported in the November 3 *Journal of Neuroscience*, researchers at the National Institute of Mental Health found evidence of seasonal differences in dopamine—a chemical messenger involved in motivation, pleasure, movement and learning.

Using brain scans, psychiatrist Daniel Eisenberg and his colleagues measured dopamine levels in the brains of 86 healthy people at different times of the year. People scanned in the fall and winter had an average dopamine signal 4.3 percent greater than those scanned in the spring and summer in an area that receives messages from dopamine-carrying neurons.

Eisenberg says future work will have to test whether dopamine levels in individuals fluctuate with the seasons the same way or if this result reflects some other difference unrelated to season between the groups, which were similar in age, sex and ethnicity. If the pattern holds, it means environmental cues that change seasonally, such as the amount of sunlight we see, may actually mold our brain state.

Eisenberg says this type of dopamine fluctuation could contribute to the winter sluggishness and summertime pep experienced by many healthy people. It may also provide clues to the winter onset of seasonal affective disorder, as well as seasonal symptom changes noted in psychiatric illnesses such as schizophrenia.

—Michelle Solis

## Monkey in the Mirror

Could rhesus macaques be self-aware?

Looking in the mirror and recognizing oneself was long thought to be an ability reserved for humans. Recently, however, researchers have found that other apes, such as chimpanzees and gorillas, seem to show signs of self-awareness, including recognizing and inspecting themselves in a mirror. Now one group of investigators claims that rhesus macaques have joined this elite group of self-aware animals.

Luis Populin, a neuroscientist at the University of Wisconsin–Madison, noticed that the macaques in his lab were doing something strange. The monkeys, in whom Populin had implanted electrodes for an unrelated study, seemed to be using mirrors to help groom the areas around the implant. They also appeared to be looking in mirrors to view their genitals.



Populin and his colleagues reported in *PLoS ONE* in September that the monkeys spent significantly less time looking in a mirror covered with black canvas than a regular mirror. He also reported that the macaques were using a large mirror to view areas of their body they could not otherwise see. Both these results, the researchers claimed, indicate that macaques are self-aware.

The problem is that rhesus macaques have not yet passed the standard measure of self-awareness, known as the mark test. In this experiment, researchers anesthetize an animal and attach a small red dot to the middle of its forehead, where the dot will go unnoticed unless the animal can recognize itself in a mirror. Psych-

ologist Gordon Gallup, currently at the University of Albany, S.U.N.Y., developed the test with chimpanzees. When Gallup's chimps woke up and were given a mirror, they peered into the mirror while touching the red dot, indicating that they noticed the change in their appearance. Populin tried the test on his macaques, and they failed to notice the dot—and therefore, Gallup says, they cannot be self-aware.

Populin, however, believes that the problem lies in Gallup's test. "The standard mark does not seem to be relevant enough for the macaques to care," Populin says.

Gallup disagrees. "Many people have tested rhesus monkeys for self-recognition, and nobody has ever found compelling evidence," he notes. "There are too many alternative explanations for why the monkeys touched their acrylic implants." For instance, they could have been responding to the physical sensation of the implants—and they just happen to like sitting in front of a mirror.

—Carrie Arnold

# Knowing Me, Knowing You

How social intuition goes awry in individuals who have autism

BY BRUCE M. HOOD

AT THE END of *Casablanca*, when Humphrey Bogart finally tells Ingrid Bergman to get on the plane back to her husband, the young mother watching the afternoon TV movie sheds a tear. Instinctively, her two-year-old tries to comfort her by offering his teddy bear to her. Both the mother and child are displaying intuitive awareness of others' mental states and emotions.

Social intuition comes naturally to most of us, but not all. Autism is a developmental disorder that affects around one in 500 individuals (although this figure appears to be on the rise and depends largely on how you define it). In general, autism can be thought of as a disorder with three major disabilities: a profound lack of social skills, poor communication and repetitive behaviors. It is regarded as a spectrum disorder because it covers a broad range and individuals vary in the extent to which they are affected. All those with the disorder share problems with social intuition, however.

Individuals with autism have a problem with socializing because they lack a repertoire of developmental social skills that enable humans to become expert mind readers. Not mind reading in the way Spock from *Star Trek* could do, but rather the capacity to infer what others are thinking in different circumstances.



Most of us have the ability to empathize with the emotional states of others—a capacity for intuitive awareness that can readily be observed from early childhood.

Over the course of early childhood typical youngsters increasingly become more sophisticated at understanding that other people have mental states that motivate their behavior. For example, if you leave your bag in the office, then I know that you believe it to be there even though the cleaner has handed it in to lost and found. I can understand you hold a false belief. This ability is called having a “theory of mind,” and it is a

natural ability in typical children. By the time the average child is around four years old, he or she interprets other people as being goal-directed and purposeful and as having preferences, desires, beliefs and even misconceptions. Without this repertoire of social skills, a human is effectively mind blind—unable to understand what others are thinking and why they do the things they do.

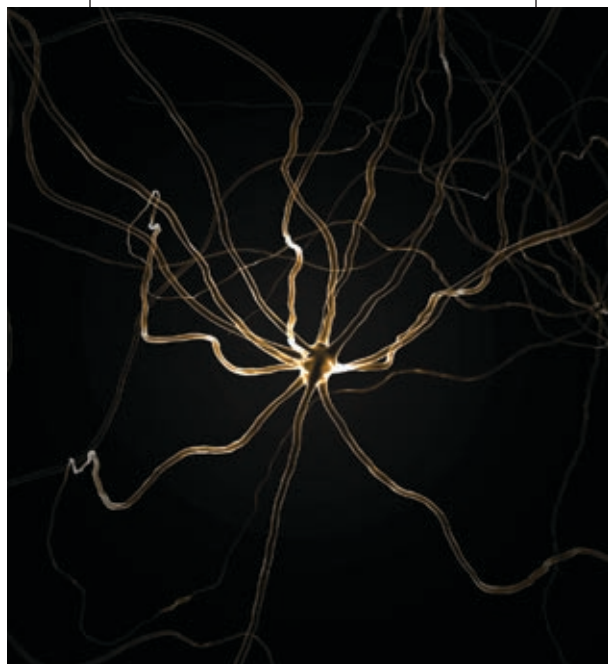
Not only do typical children become

( Individuals who have autism do not join in with the **rich tapestry** of social signals we share. )

GETTY IMAGES

Spindle neurons have been found solely in species that are social, including the **great apes**, elephants and whales.

intuitive mind readers, but they also become agony aunts as well. They begin to understand others' sadness, joy, disappointment and jealousy as emotional correlates of the behaviors that make humans do the things they do. Again, by four years of age, children have become expert at working the social arena. They will copy, imitate, mimic and generally empathize with others, thereby signaling that they, too, are part of the social circles that we all must join to become members of the tribe. They share the same socially contagious behaviors of crying, yawning, smiling, laughing and pulling disgusted faces that signal they share the same emotional experiences of those around them.



Are Von Economo (spindle) neurons a key to understanding the development of social cognition in humans and other species?

between brain regions that are activated by social learning. This location may explain why spindle neurons have been found solely in species that are particularly social, including all the great apes, elephants, and whales and dolphins.

Humans have the biggest population of spindle neurons located in the frontoinsula and anterior cingulate cortex areas—the same regions that may be disrupted in autism spectrum disorder. Spindle neurons are thought to work by keeping track of social experiences, leading to a rapid appreciation of similar situations in the future. They provide the basis of intuitive social learning when we watch and copy others. It may be no coincidence that the density of spindle neurons in these social regions increases from infancy to reach adult levels somewhere around the fourth birthday in typical children, the watershed when most child development experts agree that there is noticeable change in social intuition skills. This may also explain why individuals with autism, who have disrupted frontoinsula and anterior cingulate cortical areas, have difficulty working out what the rest of us just know without having to think very much. **M**

### Baffled by Behavior

No wonder individuals with autism find direct social interaction frightening. If you cannot figure out other people, then such interaction must be intensely baffling and stressful. They often do not like direct eye contact, do not prefer to look at faces compared with other things, do not copy, do not mimic, do not yawn when others yawn or retch when others retch, or laugh or join in with the rich tapestry of social signals we share as a species. This inability may be why individuals with autism generally withdraw into activities that do not involve other people.

The incidence of autism is higher in identical twins, who share nearly 100 percent of their genes, compared with fraternal twins, who share only 50 percent, which indicates that there is a genetic component to the disorder. Also, the greater incidence in males compared with females strongly implicates a biological basis. To date, tantalizing evidence exists based on brain-imaging

studies that regions in the prefrontal cortex—most notably the frontoinsula and the anterior cingulate cortex, which are activated by social interaction in normal individuals—are relatively inactive in individuals with autism. Autopsy data also indicate that the frontoinsula and the anterior cingulate cortex structures are abnormal in autism disorder.

John Allman of the California Institute of Technology thinks that much of this social deficit may come down to a lack of a special class of spindle neurons after their discoverer, who made the observation in 1925. Spindle neurons consist of a very large bipolar neuron that is found only in the frontoinsula and anterior cingulate cortex and thought to provide the interconnection

dle neurons in these social regions increases from infancy to reach adult levels somewhere around the fourth birthday in typical children, the watershed when most child development experts agree that there is noticeable change in social intuition skills. This may also explain why individuals with autism, who have disrupted frontoinsula and anterior cingulate cortical areas, have difficulty working out what the rest of us just know without having to think very much. **M**

BRUCE M. HOOD is director of the Bristol Cognitive Development Center at the University of Bristol in England, author of *SuperSense: Why We Believe in the Unbelievable* (HarperOne, 2009) and the forthcoming *The Self Illusion*.

### (Further Reading)

- ◆ **Autism: Explaining the Enigma.** Second edition. Uta Frith. Wiley-Blackwell, 2003.
- ◆ **The Curious Incident of the Dog in the Night-Time.** Mark Haddon. Illustrated edition. Vintage, 2004.

# Being John Malkovich

An advanced brain-machine interface enables patients to control individual nerve cells deep inside their own brain

BY CHRISTOF KOCH



IN PHILOSOPHY OF MIND, a “cerebroscope” is a fictitious device, a brain-computer interface in today’s language, which reads out the content of somebody’s brain. An autocerebroscope is a device applied to one’s own brain. You would be able to see your own brain in action, observing the fleeting bioelectric activity of all its nerve cells and thus of your own conscious mind. There is a strange loopiness about this idea. The mind observing its own brain gives rise to the very mind observing this brain. How will this weirdness affect the brain? Neuroscience has answered this question more quickly than many thought possible. But first, a bit of background.

Epileptic seizures—hypersynchronized, self-maintained neural discharges that can sometimes engulf the entire brain—are a common neurological disorder. These recurring and episodic brain spasms are kept in check with drugs that dampen excitation and boost inhibition in the underlying circuits. Medication does not always work, however. When a localized abnormality, such as scar tissue or developmental miswiring, is suspected of triggering the seizure, neurosurgeons may remove the offending tissue.

To minimize side effects, it is vital to pinpoint the location from which the seizures originate; neuropsychological testing, brain scans and EEGs aid this determination. But if no structural pathologies are apparent from the outside, doctors begin with an invasive procedure. The neurosurgeon inserts a dozen or so electrodes into the soft tissue of the brain, via small holes drilled through the skull, and leaves them in place for a week or so. During this time, the patient lives and sleeps in the hospital ward, and the signals from the wires are monitored continuously. When a seizure occurs, doctors triangulate the origin of the aberrant electrical activity. Subsequent destruc-



“Cerebroscope” that shows what people are thinking is fictional—but science is finding ways to track thoughts.

tion or removal of the offending chunk of tissue reduces the number of seizures—sometimes eliminating them entirely.

Neurosurgeon and neuroscientist Itzhak Fried of the David Geffen School of Medicine at U.C.L.A. is one of the world’s foremost specialists in this demanding trade, which requires great technical finesse. Fried and his colleagues perfected a variant of epilepsy monitoring in which the electrodes are hollowed out. This alteration permits them to insert tiny wires straight into the gray matter. Using appropriate electronics and fancy signal-detection algorithms, these miniaturized electrodes pick up the faint chattering of a bevy of just 10 to 50 neurons from the ceaseless background cacophony of the electrical activity of billions of cells.

### From Senses to Memories

Under Fried’s supervision, a group from my laboratory—Rodrigo Quian

Quiroga, Gabriel Kreiman and Leila Reddy—discovered a remarkable set of neurons in the jungles of the medial temporal lobe, the source of many epileptic seizures. This region, deep inside the brain, which includes the hippocampus, turns visual and other sensory percepts into memories.

We enlisted the help of several epileptic patients. While they waited for their seizures, we showed them about 100 pictures of familiar people, animals, landmark buildings and objects. We hoped one or more of the photographs would prompt some of the monitored neurons to fire a burst of action potentials. Most of the time the search turned up empty-handed, although sometimes we would come upon neurons that responded to categories of objects, such as animals, outdoor scenes or faces in general. But a few neurons were much more discerning. One hippocampal neuron responded only

CHRISTOF KOCH (Koch); MORAN CERF (Monroe projection)

to photos of actress Jennifer Aniston but not to pictures of other blonde women or actresses; moreover, the cell fired in response to seven very different pictures of Jennifer Aniston. We found cells that responded to images of Mother Teresa, to cute little animals and to the Pythagorean theorem,  $a^2 + b^2 = c^2$ .

Such cells, together with their sisters—for there are probably thousands of such cells in the medial temporal lobe for any one idea—encode a concept, such as Jennifer Aniston, no matter whether the patient sees or hears her name or looks at her picture. Think of them as the cellular substrate of the Platonic ideal of Jennifer Aniston. Whether the actress is sitting or running, whether her hair is up or down, as long as the patient recognizes Jennifer Aniston, those neurons are active.

Nobody is born with cells selective for Jennifer Aniston. Like a sculptor patiently releasing a *Venus de Milo* or *Pietà* out of blocks of marble, the learning algorithms of the brain sculpt the synaptic fields in which concept neurons are embedded. Every time you encounter a particular person or object, a similar pattern of spiking neurons is generated in higher-order cortical regions. The networks in the medial temporal lobe recognize such repeating patterns and dedicate specific neurons to them. You have concept neurons that encode family members, pets, friends, coworkers, the politicians you watch on TV, your laptop, that painting you adore.

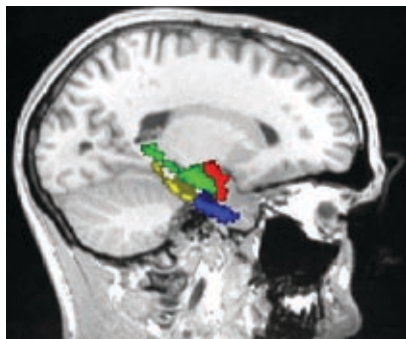
Conversely, you do not have concept cells for things you rarely encounter, such as the barista who just handed you a nonfat chai latte tea. If you were to befriend her, meet her later in a bar and let her into your life, the networks in the medial temporal lobe would recognize that the same pattern of spikes occurred repeatedly and would wire up concept cells to represent her.

Concept cells demonstrate compellingly that the specificity of conscious experience has a direct counterpart at the cellular level. Say you are recalling the iconic scene of Marilyn Monroe standing on a subway grill, trying to keep the wind from blowing her skirt up. This conscious percept will be caused by a coalition of

neurons numbering perhaps in the hundreds or thousands rather than in the billions, as is commonly assumed.

### Making Concepts Visible

More recently, Moran Cerf and others from my lab, together with Fried, hooked several concept cells to an external display to visualize a patient's thoughts. The



Four regions of the medial temporal lobe (color highlights) were sampled by a surgeon's electrodes.

idea is deceptively simple but fiendishly difficult to implement. It required three years of effort by Cerf, a computer-security specialist and a moviemaker turned Caltech graduate student, to pull off this feat. Let me walk you through one example. Cerf recorded from a neuron that fired in response to images of actor Josh Brolin (whom the patient knew from her favorite movie, *The Goonies*) and from another neuron that fired in response to the Marilyn Monroe scene I just mentioned. The patient looked at a monitor where these two images were superimposed, with the activity of the two cells controlling the extent to which she saw Brolin or Monroe in the hybrid image.

Whenever the patient focused her thoughts on Brolin, the associated neuron fired more strongly. Cerf arranged the feedback such that the more this cell fired relative to the other one, the more

visible Brolin became and the more the image of Monroe faded, and vice versa. The image on the screen kept changing until only Brolin or only Monroe remained visible and the trial was over. The patient loved it, as she felt that she controlled the movie purely with her thoughts. When she focused on Monroe, the associated neurons increased their firing rate, the cells for the competing concept, Brolin, dampened their activity, whereas the vast majority of neurons remained unaffected.

It might appear as if there are two people involved in this experiment, the way the puppeteer Craig occupied the head of actor John Malkovich in the 1999 movie *Being John Malkovich*. One is the patient's mind, instructing her brain to think of Monroe. The other is the one that is acting out the mind's desire—namely, the nerve cells in the medial temporal lobe that up- and down-regulate their activity accordingly. But both are part of the same brain. So who is in control of whom? Who is the puppeteer, and who the puppet?

All the weirdness of the mind-body nexus is apparent here. The patient doesn't feel an itch every time the Monroe neuron fires; she doesn't think, "Inhibition, inhibition, inhibition," to banish Brolin from the screen. She has absolutely no idea whatsoever what goes on inside her head. Yet the thought of Monroe translates into a particular pattern of neuronal activity. Events in her phenomenal mind find their parallel in her material brain. A mind-quake occurs simultaneously with a brain-quake. **M**

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- ◆ **On-line, Voluntary Control of Human Temporal Lobe Neurons.** M. Cerf et al. in *Nature*, Vol. 467, pages 1104–1108; October 28, 2010.
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# The Ghost Hand Illusion

Spooky fun with afterimages

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

**STARE** at the tiny, central black fixation spot on the white cross in *a*. After 30 seconds, transfer your gaze to a neutral gray background. You should see a dark—almost black—cross fading in and out. It is especially pronounced if you blink your eyes to revive the image to slow down the fading.

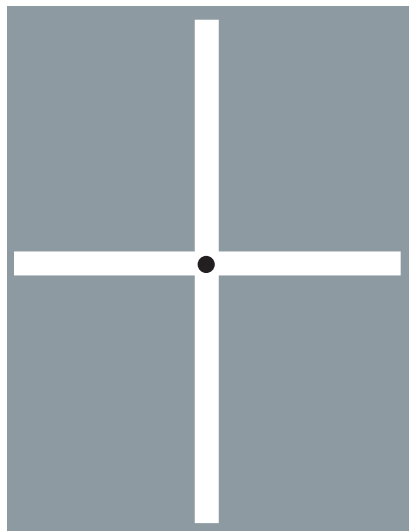
This effect is called a negative afterimage because the persistent ghost of the cross is the opposite of what you were looking at—it is dark instead of light. When you fixated on the white cross, you “fatigued” the retinal light receptors by bleaching out the cone pigments. So when you look at neutral gray, the region corresponding to where the white cross had been fires less vigorously than the surrounding area, and the net result is that it is seen as a dark cross.

Why does the cross fade? Partly because the fatigued receptors recover slowly as the bleached pigment regenerates. In contrast, with real images our eyes are in constant motion—images sail and jerk across the retina as we scan rooms, roads, texts or faces to identify novel or important bits. This continual movement prevents adaptation or fatigue because new patterns are constantly on any retinal area. With intense focus, you can eliminate all voluntary movements, and you should notice certain objects slowly fade away, as in *b* (termed the Troxler effect or Troxler fading). This fading is intermittent because your eyes never completely stop moving. Microscopic involuntary trembling characterizes even the steadiest fixation. This “physiological nystagmus” allows the brain’s edge-detecting neurons to avoid being fatigued, even during fixation, by providing moment-to-moment refreshing. But an afterimage, unlike a real image, remains stuck to the retina so the neurons are not refreshed and fatigue quickly kicks in.

All of what we have discussed so far



is the conventional story. But there is much more to afterimages than meets the eye, as shown by the late Richard L. Gregory of the University of Bristol in England, who was the world’s preeminent perceptual psychologist. His 1966 book *Eye and Brain* launched many a student (including both of us) on a career



**a**

**Ghostly hand appears after you stare at a spot on your palm in a dark room while a friend uses a flash camera to “take your picture,” briefly fixing an image on your retina.**



in visual psychology and neurophysiology. The word “genius” is rarely used these days, but if anyone deserves the title, it would be Gregory.

Gregory studied positive afterimages because they fade more slowly and are more intense with more clearly defined borders, making them easier to study. In collaboration with Elizabeth L. Seckel of our laboratory, we have confirmed the results of many little-known experiments Gregory did on afterimages in the late 1960s. The reader might wish to try them out today.

### A Shot in the Dark

Have a friend aim a flash camera at you in a dimly lit room while you gaze at a tiny, luminous dot affixed to the center

of the flash. When he “takes your picture,” you will get a positive afterimage. The persistent firing of photoreceptors makes you see a bright white disk long after the actual flash has gone.

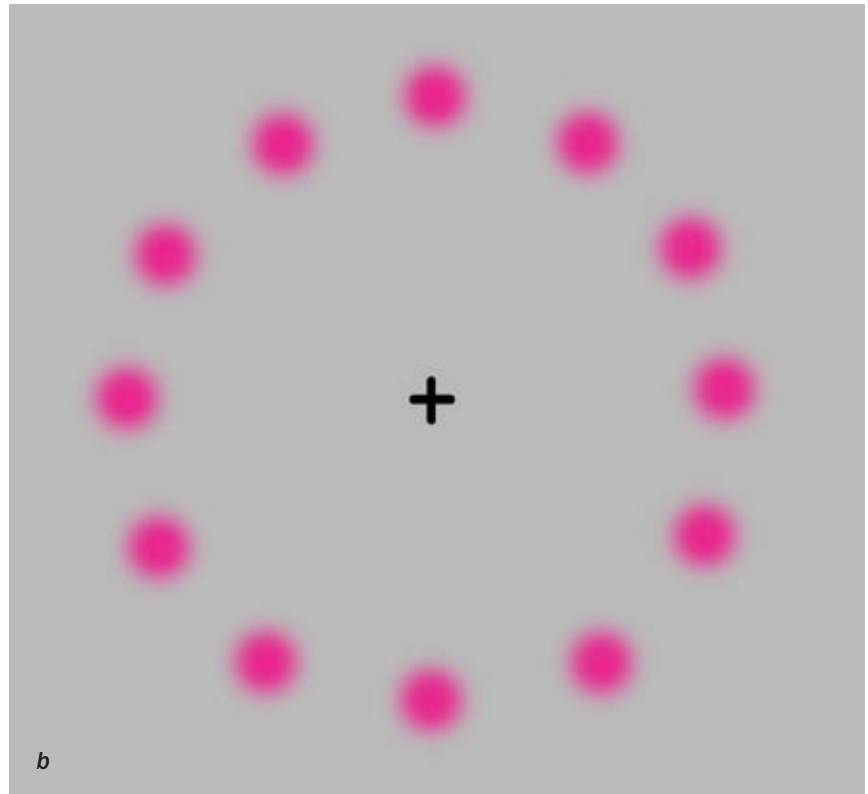
Because the afterimage is glued to the retina, if you move your eyes around the room, the afterimage moves along with them. Now, while you have an afterimage, look at surfaces at different distances. The afterimage will appear on each surface as you fixate on it, and, amazingly, its apparent size will expand or shrink depending on how far or close the surface of regard is. What fun! Hold a piece of paper at arm’s length, move it toward your nose and watch the afterimage on it change in apparent size from a Ping-Pong ball to a pea. Cast your view back to a distant wall, and instantly the afterimage appears beach-ball-sized.

Why does this effect occur? Consider real objects. For example, if a friend standing five feet from you starts walking away, her retinal image size shrinks as she leaves. At 10 feet, it is half as tall (simple geometry). But of course, you do not see her shrinking—only as moving farther away. Perceived size varies directly with perceived distance (known as Emmert’s law). And in judging distance, the brain weighs information from motion, stereo, perspective, vergence angle, and so forth and applies the necessary “corrections”—a process called size constancy.

Usually this process is adaptive in that it allows you to perceive the object as it really is: constant in size regardless of distance and retinal image size. But in the case of an afterimage, the processing backfires. The afterimage does not change size on the retina with changes in viewing distance, but your brain still interprets it as doing so. Thus, when the afterimage is superposed on a far wall, your brain expects the retinal image to have shrunk from the size it would have been on a near wall. Your brain therefore expands the apparent size to compensate. It is important to realize that all this occurs on a kind of autopilot. There is no conscious reasoning or decision making such as: “If the object is far, it must have a small image; therefore, object size must

be....” That type of cogitation would be much too time-consuming to be effective. Why this entire process results in the image actually looking large rather than simply knowing it is large is a \$64,000 philosophical question called the riddle of qualia. (We will stay away from this

you. When you stick your neck out, you will find that the afterimage shrinks because the brain “assumes” it is a real object expanding and therefore applies a (false) correction. Perhaps signals from the neck muscles are sent to the visual centers to zoom the perceived size. Alter-



**Disappearing spots:** Stare at the fixed point in the middle, with the spots in your peripheral vision. Neural “fatigue” will make the surrounding spots briefly disappear.

question in this column, even though we personally believe size constancy might one day help solve the riddle more readily than asking, “Why is red *red*?”)

Emmert’s law also works in complete darkness. This is because when you look at an imaginary object at different distances, the angle between the two eyes’ lines of sight (vergence angle) changes, and the brain measures this change in eye position. So the afterimage shrinks and expands in darkness, depending on how far away you gaze.

Next try the following experiment. Generate an afterimage with another flash. Then, in darkness, stand perfectly upright and move your head forward and back from the (invisible) wall in front of

natively, when the motor-command centers in the brain send commands to neck muscles, they may send a kind of cc (as in e-mail) to the visual centers.

### Ghostly Apparition

These facts about Emmert’s law are pretty straightforward, but the best is yet to come.

Affix a tiny, luminous spot on the center of your right palm and, in complete darkness, hold your hand out at arm’s length and look at the spot. Have a friend look over your shoulder, then take a flash aimed at your outstretched hand.

Now look straight head. You will see a vivid ghostly afterimage of your hand. Keep gazing forward so that the hand

( Move your real hand toward your nose, and you will get the impression that **the hand image is shrinking.** )

image is hovering in front of you—nothing surprising so far. But now move your real hand toward your nose, and you will get the impression that the hand image is shrinking. This miniaturization will happen even if there is an image in only one eye, so the source of distance information cannot be the vergence angle.

Gregory’s ingenious idea was that the proprioceptive information from muscle and joint sense in the arm must be going all the way to the brain’s size-perception centers; the messages do not have to originate in the eye muscles. The effect feels spooky, because you would expect your real hand image to grow as it approaches your nose, but (try it in a fully lit room) it actually shrinks because of proprioception, driven by Emmert’s law. The arm muscles are telling your brain that the glowing hand is approaching you, yet it appears to expand. So you are startled. Moreover, if you move the hand too close to yourself, the expansion of the ghost ceases. This result may occur because you do not usually bring or see your hand that close, so your size-constancy mechanisms are not “wired” for it. It might be equally interesting to affix a long dummy arm to artificially lengthen your arm to see what happens.

**Crumbling Images**

Here is another experiment with the same setup. Move your hand away from its afterimage so that the afterimage remains out in front, but the hand is not. If you are like most of us, you will see the afterimage suddenly starting to fragment, the so-called crumble effect reported in 1973 by P. Davies, then at the University of Aberdeen in Scotland. This breaking apart happens because the brain is confronted with a discrepancy between the visual location of the afterimage and the proprioceptive location of the arm. Abhorring discrepancies, the brain simply starts “shutting down” one image. It is easier to halt an evanescent,

inherently unstable afterimage than to shut down muscle and joint sense from the arm. So the image starts to fade and fragment. (Our colleague Stuart Anstis of the University of California, San Diego, has pointed out to us that the effect also occurs for other body parts.)

Another surprising effect takes place if you hold your right hand out in front of you in complete darkness so that congruence is reestablished, and the afterimage of the hand once again robustly reappears. Now move your *left* hand in between your nose and outstretched right hand (and its afterimage). You would not normally expect anything to happen because, unlike a real glowing right hand, which would be occluded by the interposed left hand, the afterimage should not be occluded—it is still stuck on the retina and should now be seen “superimposed” on the (albeit invisible) left hand. Astonishingly, in at least some trials, the afterimage becomes “occluded,” just as a real hand would—as if the mere expectation is enough to make it fade.

Do these effects occur only with hands, or can they happen for the entire body? By using a suitable placement of the flash camera in front of you while you look down on your own body, it is possible to create an afterimage of your entire body. It helps to wear white clothes, so the afterimage is brighter. (We did this experiment in collaboration with Seckel.) If you now tilt your eyes and head up to look straight ahead, a ghostly apparition of your body will start floating upward away from your real body, creating a momentary feeling of instability. More surprisingly, when we tried the experiment on a patient with chronic intermit-



**Color afterimage:** Fixate your gaze on the black spot in the center of the bottom image. After 30 seconds, look at the center of the black-and-white image of the Manzanares el Real Castle, near Madrid, Spain, on top. ¡Olé! The Spanish castle is in color.

tent bodily pain, the discrepancy seemed to alter the pain—sometimes increasing it momentarily but mostly reducing it. It remains to be seen if the effect is merely wish-fulfilling suggestibility or a real sensory phenomenon.

Using a powerful flashgun, the reader might wish to try other ingenious variations on the theme. What if you were to superpose the afterimage of the hand on your hand and wiggle your fingers? Have fun! **M**

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

**(Further Reading)**

- ◆ **Changes in the Size and Shape of Visual After-Images Observed in Complete Darkness during Changes of Position and Space.** R. L. Gregory, J. G. Wallace and F. W. Campbell in *Quarterly Journal of Experimental Psychology*, Vol. 11, pages 54–55; February 1959.
- ◆ **Eye and Brain.** Fifth edition. Richard L. Gregory. Princeton University Press, 1997.
- ◆ **Seeing through Illusions.** Richard L. Gregory. Oxford University Press, 2009.

JOHN SADOWSKI



# (calendar)



## March

**10** There is still plenty we do not know about language. For instance, scientists recently uncovered a language called Koro, spoken by only 800 people in northeastern India. And another study showed that we automatically distrust what people say when they speak with a foreign accent. As Harvard University psychologist **Alfonso Caramazza** will explain in a lecture, scientists often make inferences about how the normal language system works by examining people who have damage to the areas of the brain that process language. Caramazza will also try to map the language centers of the brain using magnets, which can temporarily disable neural regions.  
*Santa Barbara, Calif.*  
[www.sagecenter.ucsb.edu/lecture.htm](http://www.sagecenter.ucsb.edu/lecture.htm)

**10** Scientists who are dedicated to unraveling the complexities of a disease often become obsessed. But sometimes an obsession with research can become a kind of disease in itself. In Sharr White's new play **The Other Place**, which extends through April 24 at the MCC Theater, scientist Juliana Smithton is consumed by her investigation of the molecular basis of Alzheimer's. But just as she comes close to a potential therapeutic breakthrough, Smithton inexplicably finds herself battling memory loss and other symptoms characteristic of the disease she is trying to cure.  
*New York City*  
[www.mcctheater.org/currentseason.html](http://www.mcctheater.org/currentseason.html)

**17-19** The magic stays with us long after we have outgrown the fantasy novels and stopped believing in Santa Claus. Humans are hardwired to find patterns and cause-and-effect relationships, but when we cannot find any, we naturally turn to the supernatural to explain a situation. At the three-day **Second Global Conference on Magic and the Supernatural**, researchers will discuss the neuroscience of magical thinking and the ways some traumatized individuals try to cope with abuse and tragedy by attributing their suffering to mystical forces or imaginary beings instead of admitting that someone they love has hurt them.  
*Prague, Czech Republic*

**21** Is there a psychological basis for racism? One thought is that our brains evolved to notice anyone who is different from us. A new study has found that mirror neurons, which help us mimic and empathize with others, are less likely to fire in response to someone of a different race. But we have the power to overcome our prejudiced impulses. During the **United Nations International Day for the Elimination of Racial Discrimination**, we can remember the mistakes and celebrate the progress we have made to try to eliminate race-based discrimination.  
*Worldwide*  
[www.un.org](http://www.un.org)

## April

**26-30** People who live to age 100 in good health often have brain lesions that are characteristic of Alzheimer's disease. Somehow these sprightly centenarians show no signs of dementia. Scientists think this remarkable resilience is largely explained by a unique set of longevity genes—if you have a centenarian relative, your chances of living a long life are much higher than average. But lifestyle choices—namely, diet and exercise—also make a big difference. Scientists will gather at the five-day **Aging in America** conference to discuss potential causes and treatments for Alzheimer's and related dementia.  
*San Francisco*  
[www.agingconference.org](http://www.agingconference.org)

## MUSEUM ROUNDUP

### Exploring Who We Are

**Three museum exhibits probe the mind, exploring how early psychologists tried to do so, how we attempt to define ourselves and what makes us tick.**



#### Ongoing

Without fancy neuroimaging technology, how did early psychologists probe our minds? At the London Science Museum's **Mind Your Head** exhibit, you can experiment with models of historical tools that psychologists once used to study people's personality and intelligence. Test your spatial memory with the Visualization of Cubes Test, which psychologist Colin Elliott originally devised in 1983 to evaluate cognitive functioning in adolescents. And in the Telling Stories display, learn how early psychoanalysts relied on the power of storytelling, or the "talking cure," to help patients work through their problems.  
*London*  
[www.sciencemuseum.org.uk](http://www.sciencemuseum.org.uk)

Many people think genes determine ethnicity. But as the exhibit **Race: Are We So Different?** at the Boston Science Museum explains, although certain genes are more common in various races, there is no set of Asian genes or Hispanic genes. Ethnicity is largely a social construct: we tend to create divisions in our minds based on physical appearance.  
*Boston*  
[www.mos.org](http://www.mos.org)

Psychologists asked participants to lie inside a functional MRI scanner next to a live corn snake—all in the name of science, of course. The findings revealed that a brain region called the subgenual anterior cingulate cortex (sgACC) is associated with courage: the participants who were able to control their fear effectively and get closest to the snake showed the highest activity in the sgACC. Find out how your brain handles fear at the Virginia Science Museum's **Goose Bumps! The Science of Fear**, where you can conquer the terror of falling or your phobia of public speaking.  
*Richmond, Va.*  
[www.smv.org/visitingexhibits.html](http://www.smv.org/visitingexhibits.html)

JAMIE BEEDEEN Corbis Outline (magician); PASIEKA SPL/Photo Researchers, Inc. (head with brain)

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# Living in a Dream World

Daydreaming can help solve problems, trigger creativity, and inspire great works of art and science. When it becomes compulsive, however, the consequences can be dire

By Josie Glausiusz

When Rachel Stein (not her real name) was a small child, she would pace around in a circle shaking a string for hours at a time, mentally spinning intricate alternative plots for her favorite television shows. Usually she was the star—the imaginary seventh child in *The Brady Bunch*, for example. “Around the age of eight or nine, my older brother said, ‘You’re doing this on the front lawn, and the neighbors are looking at you. You just can’t do it anymore,’” Stein recalls. So

she retreated to her bedroom, reveling in her elaborate reveries alone. As she grew older, the television shows changed—first *General Hospital*, then *The West Wing*—but her intense need to immerse herself in her imaginary world did not.

“There were periods in my life when daydreaming just took over everything,” she recalls. “I was not in control.” She would retreat into fantasy “any waking moment when I could get away with it. It was the first thing I wanted to do when I woke up in the morning. When I woke up in the night to go to the bathroom, it

would be bad if I got caught up in a story, because then I couldn’t go back to sleep.” By the time she was 17, Stein was exhausted. “I love the daydreams, but I just felt it was consuming my real life. I went to parties with friends, but I just couldn’t wait to get home. There was nothing else that I wanted to do as much as daydreaming.”

Convinced that she was crazy, she consulted six different therapists, none of whom could find anything wrong with her. The seventh prescribed Prozac, which had no effect. Eventually Stein began tak-

PHOTOILLUSTRATION BY AARON GOODMAN



ing another antidepressant, Luvox, which, like Prozac, is also a selective serotonin reuptake inhibitor but is usually prescribed for obsessive-compulsive disorder. Gradually she brought her daydreaming under control. Now age 37, she is a successful lawyer, still nervously guarding her secret world.

fantasies may be followed by feelings of dread and shame, and they may compare the habit to a drug or describe an experience akin to drowning in honey.

The recent discovery of a network in the brain dedicated to autobiographical mental imagery is helping researchers understand the multiple purposes that day-

dreaming serves in our lives. They have dubbed this web of neurons “the default network,” because when we are not absorbed in more focused tasks, the network fires up. The default network appears to be essential to generating our sense of self, suggesting that daydreaming plays a crucial role in who we are and how we integrate the outside world into our inner lives. Cognitive psychologists are now also examining how brain disease may impair our ability to meander mentally and what the consequences are when we just spend too much time, well, out to lunch.

## Most people spend about 30 percent of their waking hours spacing out, drifting off, lost in thought, woolgathering—or, as one scientist put it, “watching your own mental videos.”

The scientific study of people such as Stein is helping researchers better understand the role of daydreaming in normal consciousness—and what can happen when this process becomes unhealthy. For most of us, daydreaming is a virtual world where we can rehearse the future, explore fearful scenarios or imagine new adventures without risk. It can help us devise creative solutions to problems or prompt us, while immersed in one task, with reminders of other important goals. For others, however, the draw of an alternative reality borders on addiction, choking off other aspects of everyday life, including relationships and work. Starring as idealized versions of themselves—as royalty, raconteurs and saviors in a complex, ever changing cast of characters—addictive daydreamers may feel enhanced confidence and validation. Their

on daydreams in his 1975 book, *The Inner World of Daydreaming* (Harper & Row), divides daydreaming styles into two main categories: “positive-constructive,” which includes upbeat and imaginative thoughts, and “dysphoric,” which encompasses visions of failure or punishment. Most people experience both kinds to a small or large degree.

Other scientists distinguish between mundane musings and extravagant fantasies. Michael Kane, a cognitive psychologist at the University of North Carolina at Greensboro, considers “mind wandering” to be “any thoughts that are unrelated to one’s task at hand.” In his view, mind wandering is a broad category that may include everything from pondering ingredients for a dinner recipe to saving the planet from alien invasion. Most of the time when people fall into mind wandering, they are thinking about everyday concerns, such as recent encounters and items on their to-do list. More exotic daydreams in the style of James Thurber’s grandiose fictional fantasist Walter Mitty—such as Mitty’s dream of piloting an eight-engine hydroplane through a hurricane—are rare.

Humdrum concerns figured prominently in one study that rigorously measured how much time we spend mind wandering in daily life. In a 2009 study Kane and his colleague Jennifer McVay asked 72 U.N.C. students to carry PalmPilots that beeped at random intervals eight times a day for a week. The subjects then recorded their thoughts at that moment on a questionnaire. About

Most people spend about 30 percent of their waking hours spacing out, drifting off, lost in thought, woolgathering, in a brown study or building castles in the air. Yale University emeritus psychol-

### Videos in the Mind’s Eye

Most people spend about 30 percent of their waking hours spacing out, drifting off, lost in thought, woolgathering, in a brown study or building castles in the air. Yale University emeritus psychol-

#### FAST FACTS

#### Inner World

**1** >> Daydreams are an inner world where we can rehearse the future and imagine new adventures without risk. Allowing the mind to roam freely can aid creativity—but only if we pay attention to the content of our daydreams.

**2** >> Neuroscientists have identified the “default network”—a web of brain regions that become active when we mentally drift away from the task at hand into our own reveries.

**3** >> When daydreaming turns addictive and compulsive, it can overwhelm normal functioning, impeding relationships and work.



30 percent of the beeps coincided with thoughts unrelated to the task at hand. Mind wandering increased with stress, boredom or sleepiness or in chaotic environments and decreased with enjoyable tasks. That may be because enjoyable activities tend to grab our attention.

Intense focus on our problems may not always lead to immediate solutions. Instead allowing the mind to float freely can enable us to access unconscious ideas hovering beneath the surface—a process that can lead to creative insight, according to psychologist Jonathan Schooler of the University of California, Santa Barbara.

We may not even be aware that we are daydreaming. We have all had the experiencing of “reading” a book yet absorbing nothing—moving our eyes over the words on a page as our attention wanders and the text turns into gibberish. “People oftentimes don’t realize that they’re daydreaming while they’re daydreaming; they lack what I call ‘meta-awareness,’ consciousness of what is currently going on in their minds,” he says. Aimless rambling across the moors of our imaginings may allow us to stumble on ideas and associations that we may never find if we strive to seek them.

### A Key to Creativity

Artists and scientists are well acquainted with such playful fantasizing. Orhan Pamuk, the Turkish novelist who won the Nobel Prize in Literature in 2006, imagined “another world,” to which he retreated as a child, where he was “someone else, somewhere else ... in my grandmother’s sitting room, I’d pretend to be inside a submarine.” Albert Einstein pictured himself running along a light wave—a reverie that led to his theory of special relativity. Filmmaker Tim Burton daydreamed his way to Hollywood success, spending his childhood holed up in his bedroom, creating posters for an imaginary horror film series.

Why should daydreaming aid creativity? It may be in part because the waking brain is never really at rest. As psychologist Eric Klinger of the University of Minnesota explains, floating in unfocused mental space serves an evolutionary purpose: when we are engaged with one task, mind wandering can trigger reminders of other, concurrent goals so that we do not lose sight of them. Some researchers believe that increasing the amount of imaginative daydreaming we do or replaying variants of the millions of events we store in our brains can

People’s minds typically wander to everyday concerns, such as conversations with co-workers or errands they have to run. More elaborate fantasies—such as Walter Mitty’s of piloting a plane—are far less common.

be beneficial. A painful procedure in a doctor’s office, for example, can be made less distressing by visualizations of soothing scenes from childhood.

Yet to enhance creativity, it is important to pay attention to daydreams. Schooler calls this “tuning out” or deliberate “off-task thinking.” In an as yet unpublished study, he and his colleague Jonathan Smallwood asked 122 undergraduates at the University of British Columbia to read a children’s story and press a button each time they caught themselves tuning out. The researchers also periodi-

### (The Author)

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If you are faced with a difficult decision, try not to think about the problem for a while. Instead do something else while letting your mind ramble. You may get a flash of insight from your subconscious that will lead you in the right direction.

cally interrupted the students as they were reading and asked them if they were “zoning out” or drifting off without being aware of it. “What we find is that the people who regularly catch themselves—who notice when they’re doing it—seem to be the most creative,” Schooler says. They score higher on a standard test of creativity, in which they are asked to describe all the uses of a common object such as a brick; high scorers compile a

longer and more creative list. “You need to have the mind-wandering process,” Schooler explains, “but you also need to have meta-awareness to say, ‘That’s a creative idea that popped into my mind.’”

The mind’s freedom to wander during a period of deliberate tuning out could also explain the flash of insight that may pop into a person’s head when he or she takes a break from an unsolved problem. Ut Na Sio and Thomas Ormer-

od, two researchers at the University of Lancaster in England, conducted a recent meta-analysis of studies of these brief reveries. They found that people who engaged in a mildly demanding task, such as reading, during a break from, say, a visual assignment, such as the hat-rack problem—in which participants have to construct a sturdy hat rack using two boards and a clamp—did better on that problem than those who did nothing at all. They also scored higher than those engaged in a highly demanding task—such as mentally rotating shapes—during the interval. Allowing our minds to ramble during a moderately challenging task, it seems, enables us to access ideas not easily available to our conscious minds or to combine these insights in original ways. Our ability to do so is now known to depend on the normal functioning of a dedicated daydreaming network deep in our brain.

### The Mental Matrix of Fantasy

Like Facebook for the brain, the default network is a bustling web of memories and streaming movies, starring ourselves. “When we daydream, we’re at the center of the universe,” says neurologist Marcus Raichle of Washington University in St. Louis, who first described the network in 2001. It consists of three main regions: the medial prefrontal cortex, the posterior cingulate cortex and the parietal cortex. The medial prefrontal cortex helps us imagine ourselves and the thoughts and feelings of others; the posterior cingulate cortex draws personal memories from the brain; and the parietal cortex has major connections with the hippocampus, which stores episodic memories—what we ate for breakfast, say—but not impersonal facts, such as the capital of Kyrgyzstan. “The default mode network is critical to the establishment of a sense of self,” Raichle says.

It was not until 2007, however, that cognitive psychologist Malia Fox Mason, now at Columbia University, discovered that the default network—which lights up when people switch from an attention-demanding activity to drifting reveries

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with no specific goal—becomes more active when people engage in a monotonous verbal task, when they are more likely to mind wander. In an experiment, participants were shown a string of four letters such as R H V X for one second, which was then replaced by an arrow pointing either left or right, to indicate whether the sequence should be read forwards or backwards. When one of the characters in the string appeared, subjects were asked to indicate its position (first, second, third or last, depending on the di-

fault network activity shot up. Periodically the investigators also interrupted the subjects and asked them if they had zoned out. Again, activity in the default network was higher in the seconds before the moment they were caught in the act. Notably, activity was strongest when people were unaware that they had lost their focus. “The more complex your mind-wandering episode is, the more of your mind it’s going to consume,” Smallwood says.

Defects in the default network may

coming from. People with schizophrenia daydream normally most of the time, but when they are ill, “they often complain that someone is reading their mind or that someone is putting thoughts in their head,” Williamson says.

On the other hand, those who ruminate obsessively—rehashing past events, repetitively analyzing their causes and consequences, or worrying about all the ways things could go wrong in the future—are well aware that their thoughts are their own, but they have intense dif-

**“What we find is that the people who regularly catch themselves [daydreaming]—who notice when they’re doing it—seem to be the most creative,” one psychologist says.**

rection of the arrow). The more the participants practiced on each of the four original letter strings, the better they performed. They were then given a novel task, consisting of letter sequences they had not seen before. Activity in the default network went down during the novel version of the test. Subjects who daydreamed more in everyday life—as determined by a questionnaire—also showed greater activity in the default network during the monotonous original task.

Mason did not directly measure mind wandering during the scans, however, so she could not determine exactly when subjects were “on task” and when they were daydreaming. In 2009 Smallwood, Schooler and Kalina Christoff of the University of British Columbia published the first study to directly link mind wandering with increased activity in the default network. The researchers scanned the brains of 15 U.B.C. students while they performed a simple task in which they were shown random numbers from zero to nine. Each was asked to push a button when he or she saw any number except three. In the seconds before making an error—a key sign that an individual’s attention had drifted—de-

also impair our ability to daydream. A range of disorders—including schizophrenia and depression—have been linked to malfunctions in the default network in recent years. In a 2007 study neuroscientist Peter Williamson of the University of Western Ontario found that people with schizophrenia have deficits in the medial prefrontal cortex, which is associated with self-reflection. In patients experiencing hallucinations, the medial prefrontal cortex dropped out of the network altogether. Although the patients were thinking, they could not be sure where the thoughts were

faculty turning them off. Yale psychologist Susan Nolen-Hoeksema does not believe that rumination is a form of daydreaming, which she defines as “imagining situations in the future that are largely positive in tone.” Nevertheless, she has found that in obsessive ruminators, who are at greater risk of depression, the same default network circuitry turns on that is activated when we daydream.

These ruminators—who may repeatedly scrutinize faux pas, family issues or lovers’ betrayals—have trouble switching off the default network when asked to focus mentally on a neutral image,

**Daydreaming can serve as a useful distraction. For example, conjuring up soothing scenes from the past could make a visit to the doctor more bearable.**



such as a truckload of watermelons. They may spend hours going over some past incident, asking themselves how it could have happened and why they did not react differently and end up feeling overwhelmed instead of searching for solutions. Experimental studies have shown that positive distraction—for example, exercise and social activities—can help ruminators reappraise their situation, as can techniques for cultivating mindfulness that teach individuals to pay precise attention to activities such as breathing or walking, rather than to thoughts. Yet people who daydream excessively may have the same problems ignoring their thoughts once they get going. Indeed, extreme daydreamers find their private world so difficult to escape that they describe it as an addiction—one as enslaving as heroin.

### When Daydreaming Becomes a Drug

“I’m like an alcoholic with an unlimited supply of booze everywhere I go,” says Cordellia Amethyste Rose. A 30-year-old computer science student in Oregon, she started an online forum called Wild Minds (<http://wildminds.net>) for people who simply cannot stop daydreaming. Since childhood, Rose has conjured up countless imaginary characters in ever changing plots. “They’ve grown right along with me, had children; some have died,” she says. The deeper she delved into her virtual world, though, the more distressed she became. “I couldn’t pay attention for more than a split second. I would look at a book and zone out after every word.” Even so, she found her invented companions more compelling than anyone real.

“I learned to socialize internally with fictional characters I get along with,” she says. She could engage them in intellectual debate, whereas “socializing with outside people frustrates me. They all want to talk about the silliest things.”

Rose says that she has no friends, but on Wild Minds she has found her peers. Many people posting to the site express relief that they have found others like themselves, emerging from a cocoon of loneliness and shame to share their experiences: misdiagnoses, lack of understanding from families and therapists, and rituals like the one described by a quiet girl who spends “endless hours” swaying in a rocking chair listening to music, daydreaming her life away. “It’s like a drug, poisoning and destroying your life,” says one anonymous fantasist, who admits to bingeing for days on a story line. “It’s even worse, because an addict can put a drug down and walk away. You can’t put down your mind and walk away from it.”

Yet few of the members of the Wild Minds community would abandon their mental creations, even if they could. One hardworking nurse revels in imagined adventures starring a fictional medieval Queen Eleanor of Scotland, a skilled horsewoman with four concurrent husbands, who practices a made-up religion and is “a genius in both state and battlecraft . . . trained in martial arts and is always inventing marvelous things.” Like Thurber’s fictional fantasist, Queen Eleanor’s creator spends a lot of time mentally rescuing disaster victims from burning buildings or “abseiling over cliffs, being winched in and out of helicopters with casualties.”

She has also documented her preposterous plots for independent biopsychological researcher Cynthia Schupak, a woman with a single-minded mission to understand compulsive daydreamers, who treated Rachel Stein and described her ordeal in a journal article published

**A pleasant reverie about a successful acting career might motivate you to work hard for a desired outcome, but it could be detrimental if you become oblivious to pickpockets or vehicular traffic.**





in 2009. Schupak is convinced that compulsive daydreaming is a unique disorder, characterized by an inability to control it and the deep distress over the condition. “Everyday escapist fantasy is fine and dandy, but this syndrome is different,” she says. Schupak has enrolled 85 sub-

inescapable realities. When their enhanced ability to conjure up vivid imagery is under control and does not interfere with social or academic success, “the phenomenon should probably be classified as a talent rather than a disorder,” he says. Attitude may also be important.

your daydreams. To distinguish between beneficial and pathological imaginings, he adds, “Ask yourself if this is something useful, helpful, valuable, pleasant, or am I just rehashing the same old perseverative thoughts over and over again?” And if daydreaming feels out of control,

## “I’m like an alcoholic with an unlimited supply of booze wherever I go,” says Cordellia Amethyste Rose, who started an online forum for people who cannot stop daydreaming.

jects—garnered mostly from Web postings—for an in-depth study of the syndrome. Respondents to her questionnaires devote between 12 and 90 percent of their waking hours to daydreaming—often while pacing, twirling or waving a string. Nearly all believe that everyday activities pale by comparison with their vivid inner worlds, and some often drift in and out of their alternative reality in the midst of conversation. Typically they report that their daydreams made them feel comforted or confident, “because it’s me, just magnified,” as one subject put it. Nevertheless, 93 percent say they feel anguished over the amount of time they spend fantasizing, admitting that their habit has prevented them from forming relationships, studying or holding down any but the duller jobs.

Schupak believes the syndrome could be a psychiatric illness, but is it? Singer, for example, believes it is nothing new: he says that he encountered many similar cases in his years of research and practice. Yet some evidence suggests that maladaptive daydreaming could be a distinctive disorder. Eight years ago clinical psychologist Eli Somer of the University of Haifa in Israel recounted cases of six people consumed by fantasy lives packed with sadism and bloodshed. All had suffered some form of childhood trauma. One had been sexually molested by her grandfather. Another described his father as a brutal man who humiliated and physically abused family members.

Somer believes that this mental activity emerged as a coping mechanism to help his patients deal with intolerable or

Singer, who grew up during the Great Depression and had no formal musical training, he says, entertained himself through childhood and adolescence with the imaginary achievements of “Singer the Composer,” an alter ego who wrote a complete repertoire of classical music, including operas and an unfinished Seventh Symphony. He does not consider his inner adventures harmful but rather sees them as a boredom-banishing sport—one that likely helped to propel him into his profession.

### Is Your Mind Wandering Out of Control?

How do you know when you have tipped over from useful and creative daydreaming into the netherworld of compulsive fantasizing? First, notice whether you are deriving any useful insights from your fantasies. “The proof is in the pudding,” Schooler says. “Creative individuals—artists, scientists, and so on—oftentimes report ideas that have occurred to them during daydreams.” Second, it is important to take stock of the content of

then even if it is pleasant it is probably not useful or valuable.

Whether or not mind wandering causes distress often depends on the context, Kane observes. “We argue that it’s not inherently good or bad; it all depends on what the goals of the person are at the time.” It may be perfectly reasonable for a scientist to mentally check out in the midst of a repetitive experiment. And a novelist who can pour her reveries onto paper and publish them is clearly putting them to good use.

“Happily, a lot of what we do in life doesn’t require that much concentration,” Kane says. “But there are going to be some contexts in which it is costly. Does the cost to your activity, to your reputation, to your performance, overwhelm the benefit that you may be getting from those thoughts? You can imagine situations where it is so costly that there’s no thought you could be having that’s worth it,” he says, pausing to consider the possibilities. “You’ve crossed the line,” he concludes, “if you walk into traffic and get killed.” **M**

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# Great Pretenders

People who experience the “impostor phenomenon” believe their successes are undeserved—and they live in constant fear of being unmasked

By Birgit Spinath

“**T**hat was a really impressive exam. Why don’t you write your dissertation on that subject? Let’s set up an appointment for you to come by, and we’ll talk about it,” said the professor to Nina after she completed a test.

Unfortunately, the up-and-coming mathematician was unable to take in and enjoy the compliment. Rather her head was full of thoughts such as “What a nice man, and

he asked me such easy test questions. That was a close call! Now I’ve got to make sure not to talk shop with him because then he’ll realize that I faked it. He’ll see right through me.” By the time Nina had finished going through her well-worn mental routine, she realized that there was no way she was going to accept her professor’s offer.

In spite of her brilliance on the examination, which required real mastery of the subject, she sees herself as a fraud. Psychologists call this the impostor phenomenon. Those who are afflicted believe that their successes cannot be attributed to their own abilities. Instead they are convinced that other people’s praise and recognition of their accom-

plishments are the result of charm, deception or simple good luck. Interestingly, such thoughts tend to surface in people—such as Nina—whose lives have been an apparently uninterrupted string of successes.

Many people have a tendency to blame external circumstances for their own accomplishments or failures. But those plagued with impostor thinking go well beyond this. They actually view themselves as swindlers who cheat their way into success without in any way having earned it. They live in constant terror of being exposed.

Recently researchers have been taking a closer look at the emotional characteristics of people

The feeling of having **conned everyone** seems to appear early in a person's college career or professional life.



A high test score may not be a welcome sight to students who think they are frauds. Doing well leads to anxiety about whether they can keep up the “charade.”

plagued by such ideas. By better understanding how the impostor phenomenon differs from related mental states such as social anxiety, depression and low self-esteem, psychologists are learning how to help people recognize and dispel the troubling thought that they are nothing but phonies.

### Feeling Like a Phony

The term “impostor phenomenon” was coined in the 1970s by psychologists Pauline Clance and Suzanne Imes, both then at Georgia State University. Clance and Imes noticed that many of their students with excellent test scores and good grades admitted during counseling that they felt they did not belong at the school. Although these students

were successful and accomplished, they expressed the idea that they had somehow conned their way into their current positions. They were astutely aware of their weaknesses and tended to overestimate the strengths and abilities of others. In their minds, they always failed to measure up—and they dreaded the day they would make a mistake and reveal to the world the grand illusion.

Clance and Imes described this impostor phenomenon in a 1978 paper, taking care not to call it a “syndrome” or a “disorder,” because it is not a debilitating medical condition. Still, such thinking can be persistently troubling for those who suffer from it, and it may even keep some people from fulfilling their potential or finding contentment.

In 1985, after further studying the associated feelings and ideas, Clance developed a questionnaire to help individuals determine if they show an impostorlike pattern of thinking [see box on opposite page]. The test, widely used today by counselors and psychotherapists, covers the three main components of such thinking: feeling like a fake, discounting praise and achievements, and attributing successes to luck. The first component, feeling fake, is the core of impostordom. People feel that they have pulled the wool over everyone's eyes—that they are not really as smart, talented or hard-working as they have convinced everyone they are. The second facet is the inability to acknowledge praise or good performance, which means that even after working hard and achieving a goal, these so-called impostors will ignore the fact of their success and continue to focus on their perceived weaknesses. And finally, when faced with their own conspicuous achievements, sufferers will attribute their good fortune to chance or some other external factor rather than taking credit for it.

This last point deserves further elaboration. Whenever people think about who or what is responsible when something good or bad happens to them, they are practicing attribution—they ascribe the cause to a particular thing. According to psychologist Martin Seligman of the University of Pennsylvania, we all have a certain style of attribution that we tend to use to explain life events. This style of attribution consists of three dimensions: the reasons can lie either within or outside our own person (internal versus external); they may be lasting or transient (stable versus unstable); and they

#### FAST FACTS

### An Imagined Swindle

- 1» Some people feel like they have fooled everyone into thinking they are smarter or more competent than they really are, despite consistently performing well and garnering praise.
- 2» This feeling of being an impostor is related to but not fully explained by depression, social anxiety and low self-esteem. It may be more common in women.
- 3» To break the cycle of self-doubt and self-sabotage, people must learn how to give themselves credit for their achievements as well as take constructive criticism about their mistakes and failures.

GETTY IMAGES

# Do You Feel Like a Fraud?

Everyone occasionally feels self-doubt. But for people who suffer from the impostor phenomenon, the feeling of being a fake is persistent and painful—despite a lifetime of success. To measure levels of impostor thinking, Georgia State University psychologist Pauline Clance developed a questionnaire in 1985 that is still the most widely used tool for impostor evaluation today. Here are some of the items on the 20-question test (available in full at [www.paulineroseclance.com](http://www.paulineroseclance.com)):

- I can give the impression that I'm more competent than I really am.
- I sometimes think I obtained my present position or gained my present success because I happened to be in the right place at the right time or knew the right people.
- I'm afraid people important to me may find out that I am not as capable as they think I am.
- I often compare my ability to those around me and think they may be more intelligent than I am.
- At times, I feel my success has been due to some kind of luck.
- I avoid evaluations if possible and have a dread of others evaluating me.
- When people praise me for something I've accomplished, I'm afraid I won't be able to live up to their expectations of me in the future.



may apply to many situations or uniquely to a single situation (global versus specific).

Attribution style has frequently been associated with emotional health. Emotionally robust people tend to attribute positive events to internal, stable and global factors (“I’m just smart!”); in contrast, with negative occurrences they tend to cite unstable and specific factors (“bad luck *this* time!”). Depressive people, on the other hand, tend to exhibit the reverse pattern: they make themselves responsible for their failures but attribute their successes to luck.

People who fit the impostor phenomenon profile use this latter style of attribution, which raises an obvious question: Are they simply depressed? In 2002 psychologist Naijean S. Bernard, then at Southern Illinois University, and her co-workers gave Clance’s questionnaire to almost 200 students. The researchers found an association between impostor thinking and depression—a finding that has since been confirmed by numerous other studies.

But depression cannot entirely account for the impostor phenomenon—and neither can other related mental states. In 2001 psychologist Scott Ross of DePauw University found that people afflicted with the impostor phenomenon are in general more apt than others to feel ashamed for one reason or another. This tendency is coupled with a general increase in fearfulness, as psychologists Shamala Kumar and Carolyn Jagacinski found in 2006 after interviewing more than 130 students at Purdue University.

Fear and shame go hand in hand with disorders and traits such as social anxiety, neuroticism and low

self-esteem, and many research groups have explored the relations between these feelings and impostorism. By administering Clance’s questionnaire to various groups of people alongside rigorous tests for social anxiety, neuroticism, low self-esteem and other related mental states, these researchers have determined that the impostor phenomenon seems to be a truly distinct experience. As expected, high scores on Clance’s test correlate with higher-than-normal scores on the surveys for social anxiety and low self-esteem—but no combination of these other psychological states can accurately identify people who report feeling like frauds or adequately describe their specific fear of having fooled the world.

## A Female Affliction?

When Clance and Imes first described the impostor phenomenon, they suggested that women might be particularly susceptible to this type of thinking. But the data on gender differences remain inconclusive. Some studies have borne out the idea that women are especially vulnerable to ideas about being a sham, including research currently being conducted by psychologist Christine Roth of the University of Heidelberg in Germany. Roth has been looking at the distribution of the phenomenon among psychology students. Because

## (The Author)

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psychology is a very competitive subject at the university, most of the students had already been quite successful in their studies—in other words, they met an important criterion for the impostor phenomenon. And in fact, the number of women in the group who reported impostor-related thinking was far larger than the number of women in the group without such feelings.

Some psychologists suggest that the phenomenon could be a possible contributing factor to the low number of women who achieve top positions in their fields. Although girls on average get better grades in school than boys, they may have a greater tendency to feel that those grades are undeserved. A *Journal of General Internal Medicine* study in 2008 of medical residents found that female residents scored higher, on average, on Clance's questionnaire than did male residents. Other studies, however, have shown no gender difference in terms of the frequency or intensity of feeling like a counterfeit. For instance, a different study in 2008, from the *Journal of Physician Assistant Education*, found no gender differ-

ence in practicing physicians' assistants' likelihood of experiencing impostor thoughts and feelings.

A possible explanation for these murky results may be that people are more likely to experience impostor feelings at certain points in their lives—and rather than being a stable trait, such thinking waxes and wanes as an individual's situation changes. According to Clance, now professor emerita at Georgia State University, the feeling of having conned everyone seems to appear for the first time at the end of high school or early in a person's college career or professional life—a time at which even those who have become accustomed to success have to meet increased challenges. Those who seemed to sail through school and get good grades without really trying may, according to Clance, have failed to learn how to prepare appropriately for performance situations or to ascribe their success to their own ability.

### Self-Sabotage

It may seem impossible that people who have always performed at a high level can fail to believe

The number of female psychology students with impostor-related thinking was **far larger than the number without.**

## Real Cheats

**T**he impostor phenomenon is defined as the mistaken feeling that one's successes are unearned and that at any moment the charade could end. The emphasis is on "mistaken"—these people are not really frauds. Or are they? Psychologist Joseph R. Ferrari of DePaul University asked this question in 2005. He studied how often self-defined impostors engaged in plagiarism and other types of dishonest behavior. His results supported the original idea that the fraudulence is all in their head: the supposed impostors reported on a survey that they cheated *less* often than control subjects who did not have impostor feelings.

Some people who score high on tests of impostor thinking may be engaged in a different kind of deception, however—albeit a more benign one. According to a 2007 study by Rory O. McElwee and Tricia Yurak of Rowan University in Glassboro, N.J., some people may adopt an impostorlike stance as a way of appearing humble or of lowering others' expectations so that their accomplishments seem more noteworthy. The psychologists built on a 2000 study from Wake Forest University in which self-styled impostors told researchers they expected to do poorly on a test, but those low expectations disappeared when they



were in private. McElwee and Yurak gave 253 students a battery of tests and found that impostor thinking looked a lot like a self-presentation strategy, rather than a character trait. Under scrutiny, the researchers conclude, we all tend to doubt our abilities and discount our strengths. —B.S.

HANS NELEMAN Corbis

in their own abilities, but that perspective may get stabilized within a closed thought loop. To ensure that their “failure” is not uncovered in a performance situation, such people may avail themselves of two seemingly opposite strategies: overdoing and underdoing. Overdoing involves disproportionate efforts such as studying and restudying material they have already mastered or obsessively preparing and practicing every detail of a short, routine presentation. This strategy certainly increases the likelihood of success. But it also springs a nasty trap: achievement seems to result not from their intrinsic abilities but from their Herculean preparations. And because they know that they will not always be able to match that effort, it strengthens the fear that their accomplishment may never be duplicated—and that eventually their “true” nature will be found out.

Underdoing looks somewhat different. Given a particular performance situation, a person will, for example, fail to prepare or prepare much too late, doing other, extraneous things instead. In the 1970s social psychologist Edward E. Jones dubbed this behavior “self-handicapping.” [For more on self-handicapping as it relates to perfectionism, see “Can You Be Too Perfect?,” by Emily Laber-Warren; *SCIENTIFIC AMERICAN MIND*, July/August 2009.] When these underdoers perform well, despite putting obstacles in their own way by not studying or preparing, they ascribe their success to luck rather than their own ability. It was just a fluke. Thus, people who have an impostor mind-set who fall into the underdoing trap end up viewing the future as just as uncertain as those who overprepare.

### Breaking the Pattern

How can this vicious cycle of impostor thinking be interrupted? Clance, who continues to work with sufferers as a psychotherapist, makes several recommendations. One central approach is to practice appropriate attribution: self-defined impostors must learn to ascribe their successes to their own abilities, to the extent justifiable. Although it is generally appropriate to say “I was successful because I worked hard,” the actual hard labor must itself be commensurate with the task at hand. Labor is not commensurate in overdoers, and therefore it is not useful for them to attribute success to the sweat of their efforts. Instead they should acknowledge the intelligence or skill that contributed to their success. And when things go wrong, people should cite factors that can be changed such as too little effort or an incorrect learning strategy.

There are other ways to disrupt impostor think-



ing and even to keep it from cropping up in the first place. One potential approach is to increase feelings of self-esteem, which simultaneously decreases fear and depression. For example, ponder the various facets of your personality, especially reflecting on your strengths, positive relationships with other people, and competence. Such introspective exercises have been shown to boost self-esteem, confidence and performance.

Research on the impostor phenomenon indicates that our conflicted student Nina is not alone. Some very successful people suffer from the feeling that they are frauds and that their successes are not a result of their own abilities. But as soon as they learn to recognize and appreciate their accomplishments, they will better be able to fulfill their potential, and they will likely find themselves enjoying a greatly renewed sense of personal worth. **M**

Some experts have suggested that women are more susceptible to feeling like impostors, and perhaps that could help explain why they are underrepresented in certain fields. Studies of such gender differences, however, have been conflicting and inconclusive.

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# YOU ARE WHAT YOU LIKE

The Beatles or Brahms, Bauhaus or Braque—your cultural preferences say a lot about your personality

*By Christiane Gelitz*

**A** friend invites you to his new apartment. As he cues up an old jazz record, you look around his cluttered room for somewhere to sit. Works of literature and philosophy are stacked waist-high next to the desk. Thumbtacks anchor a colorful Picasso print to the wall. His collection of foreign films and documentaries topples out of an unpacked box. His housemate's digs—which you spy across the hall—are a different story: a framed Monet poster hangs over the neatly made bed; top-40 CD cases and box sets of TV sitcoms line the shelves; carefully arranged gossip magazines fill a nearby rack.

GEHRN & GEIST/MANFRED ZENTSCH



Without even meeting the roommate, you are willing to bet that these two won't live together for long, and, in fact, you are probably right. An increasing number of psychological studies reveal strong associations between personality traits and aesthetic tastes. According to these investigations, the jazz aficionado—who prefers challenging books and abstract art—is more likely to be an extrovert and open to new experiences. The top-40 fan, on the other hand, probably shies away from novelty. Based on his fondness for Impressionist art, though, he is likely to be agreeable and conscientious.

Profiling of this sort is far from perfect. We all know the stereotype-busting slacker with highbrow hobbies or the scholar who loves soap operas and pop. Nevertheless, current research shows that we can, to a fair extent, judge a book's reader by its cover: if you like challenges, chances are you will seek them out in the media you consume. If you are gregarious and social, you will probably gravitate toward songs, magazines and television shows in the public eye. And if you are highly emotional, you may turn to culture and art primarily for comfort or distraction. Indeed, our personalities—perhaps even more than our intelligence or education—hold tremendous sway over what we read, listen to and watch.

### Ready for Something New?

Many studies that aim to trace our cultural proclivities back to personality track traits known as “the Big Five”: extroversion, openness, neuroticism, agreeableness and conscientiousness. How individuals score on these measures gives a broad-brush portrait of their nature. Are they reserved or social, a reflection of extroversion? Are they curious, indicating a high degree of openness, or more down-to-earth? Are they emotionally reactive, or neurotic, or not easily upset? Do they tend to be cooperative—meaning they are agreeable in temperament—or are they driven more by self-interest? Are they self-disciplined, a sign of conscientiousness, or more spontaneous in how they approach life?

Of all the Big Five traits, openness, in particular, seems to shape our fancies in the fine arts. In 2009 Tomas Chamorro-Premuzic of the University of London and his colleagues gathered data online from more than 90,000 people between the ages of 13 and 90—one of the largest such studies ever conducted. They asked respondents to rate how well they liked 24 paintings in four styles—Cubist, Renaissance, Impressionist and Japanese—and then to complete a Big Five questionnaire. Of interest, they found that only openness had a strong and consistent influence on artistic leanings: individuals who were open more often relished Cubist, Renaissance and Japanese images, whereas more conventional subjects—who typically score low in openness but high in agreeableness and conscientiousness—frequently favored Impressionist art.

Our reading material also tends to reflect our degree of cultur-





Participants who scored high in openness on a Big Five inventory tended to be fond of classic literature and of the arts and culture sections of newspapers. Openness was also common among those who liked scientific books or magazines.

al openness, according to Samuel D. Gosling of the University of Texas at Austin. In 2005 he asked test subjects to look around a room and then evaluate the person living there. His participants often inferred that spaces filled with newspapers, journals, CDs or books typically belonged to people open to new experiences. A better indicator proved to be the type, not just number, of media present. For instance, comics—as well as books about music and philosophy—revealed surprisingly little about the openness of their owners. News magazines, on the other hand, as well as books about art, poetry and psychology did more often belong to open personalities. More conservative individuals tended to possess joke collections and books about politics.

In 2004 psychologists Nicola Schutte and John Malouff of the University of New England in Armidale, Australia, surveyed 251 students and reported different associations between openness and reading preferences. Participants who scored high in openness on a Big Five inventory tended to be fond of classic literature and of the arts and culture sections of newspapers. Openness was also common among those who liked scientific books or magazines. A predilection for science writing was further linked to high levels of conscientiousness. In contrast, devotees of gossip magazines and romances scored lower

than average in openness but above average in extroversion.

Dutch researchers Gerbert Kraaykamp of the University of Nijmegen and Koen van Eijck, now at Erasmus University in Rotterdam, added to these findings in 2005, surveying more than 3,000 subjects between the ages of 18 and 70. As expected, people who described themselves as open to new things were culturally more active, independent of age, sex or level of education, and their pursuits extended beyond high art—they frequently attended pop concerts and also liked movie thrillers and crime shows. Moreover, Kraaykamp discovered that open spirits typically shunned reading romances or watching soap operas. Instead such pastimes attracted subjects who characterized themselves as more emotional.

Because many of these studies have used Big Five inventories, they are readily comparable, and, for the most part, their findings converge: people who score high in neuroticism or agreeableness tend to prefer undemanding free-time activities, which are neither intellectually nor emotionally challenging. Open individuals typically crave more complex cultural offerings. Other analyses have considered how tastes relate to sensation seeking, a character trait first described by psychologist Marvin Zuckerman in the 1970s. As the name suggests, sensation seekers yearn for excitement, readily take risks and hunger for intense experiences. Sensation seeking is considered to be one aspect of openness. In 2001 Adrian Furnham of University College London and his colleagues reported that the more a person tended toward sensation seeking, the more he or she liked abstract art, pop art and surrealism, and the more he or she disliked representational painting.

### The Beat of a Different Drum

Sensation seekers also have clear musical preferences. As Zuckerman reported some 25 years ago, they tend to enjoy rock or classical music, not film scores or hymns. More recent studies also support the idea that personality molds our musical tastes—so much so that an iTunes library of someone's favorite songs can almost serve as a psychological calling card. In 2006 Gosling and Peter Jason Rentfrow of the University of Cambridge asked subjects to listen to 10 songs and then describe the person—a stranger—who chose them. They found

#### FAST FACTS

##### Personal Possessions

- 1>> Our tastes in art, books and music reveal a great deal about our personality.
- 2>> People who are particularly open tend to prefer demanding aesthetic experiences; those who are more emotionally reactive prefer less challenging cultural pursuits.
- 3>> The high we feel from hearing a favorite song activates brain regions associated with other highs, such as that we get from eating chocolate.

## Conscientious Roses Are Red, Open Violets Are Blue ...

The Big Five personality traits also color our political leanings, according to Dana R. Carney, now at Columbia University. Americans on the left tend to be open to new experiences; those on the right are more typically conscientious (*charts below and right*). In general, she found that liberals were more open, tolerant, creative, curious, expressive, enthusiastic, and drawn to novelty and diversity. Conservatives, on the other hand, tended to be more conventional, orderly, organized, neat, clean, withdrawn, reserved and rigid.

Carney further discovered that, compared with the average U.S. citizen, liberals owned a larger variety of books and CDs, kept more painting and crafts materials in their bedrooms, saved more film tickets, and apparently traveled more often, as evidenced by collections of international maps, travel books and cultural memorabilia. Conservative homes reflected a desire for order: they more often had a calendar on the wall, as well as more cleaning and mending supplies. In addition, conservatives owned more sports paraphernalia and alcohol.

Liberal/Left-Wing Liberal/Left Wing	O	C	E	A	N
Slovenly, ambiguous, indifferent		-			
Eccentric, sensitive, individualistic	+				
Open, tolerant, flexible	+				
Life-loving, free, unpredictable	+	-	+		
Creative, imaginative, curious	+				
Expressive, enthusiastic	+		+		
Excited, sensation seeking	+		+		
Desire for novelty, diversity	+				
Uncontrolled, impulsive		-	+		
Complex, nuanced	+				
Open-minded	+				
Open to experience	+				

### NOTE:

O = Openness to experience; C = Conscientiousness; E = Extraversion; A = Agreeableness; N = Neuroticism; + = High; - = Low

Conservative/Right Wing	O	C	E	A	N
Definite, persistent, tenacious		+			
Tough, masculine, firm		+		-	
Reliable, trustworthy, faithful, loyal		+		+	
Stable, consistent		+			-
Rigid, intolerant	-			-	
Conventional, ordinary	-	+			
Obedient, conformist	-	+		+	
Fearful, threatened					+
Xenophobic, prejudiced	-			-	
Orderly, organized		+			
Parsimonious, thrifty, stingy		+			
Clean, sterile		+			
Obstinate, stubborn	-	+		-	
Aggressive, angry, vengeful				-	
Careful, practical, methodical	-	+			
Withdrawn, reserved			-		
Stern, cold, mechanical	-		-	-	
Anxious, suspicious, obsessive					+
Self-controlled		+			
Restrained, inhibited	-	+	-		
Concerned with rules, norms	-	+			
Moralistic	-	+			
Simple, decisive	-	+			
Closed-minded	-				
Conscientious		+			

that, using only these top-10 playlists, the participants could make accurate judgments about the stranger's openness to new experiences, degree of extroversion and personal values.

A few years earlier, in 2003, Gosling and Rentfrow, who was also then at the University of Texas, surveyed the musical tastes of more than 3,500 students on campus. To make the study more manageable, they distilled countless musical styles into four broad categories and found that each one seemed to attract a distinct personality profile: intense or rebellious music—including rock and punk—drew in listeners who scored above average in openness. Fans of reflective or complex music tended to be both open and politically liberal. Dynamic/rhythmic music lured

mainly extroverts, and upbeat/conventional tunes drew extroverts as well as agreeable, conscientious and politically more conservative listeners.

Marc Delsing and his colleagues at the University of Utrecht corroborated the results five years later. These researchers used data collected from a longitudinal study based on a survey com-

### (The Author)

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## High feelings experienced during favorite songs appeared to result from autonomic stimulation: moments of musical bliss were associated with increases in skin conductivity, respiratory rate and heart rate, as well as drops in blood pressure and body temperature.

pleted by more than 2,000 Dutch teens between the ages of 12 and 19. Part of the survey asked about musical tastes; it excluded genres rarely heard in Holland—for example, folk, country, blues and soundtracks—but included other varieties such as hardcore, punk and goth. Despite the differences, Delsing identified more or less the same four clusters of musical preference and personality that Gosling and Rentfrow had described. He needed to reclassify only one style to make the fit: whereas the American sample put gospel music in the same category as pop, Delsing grouped it with jazz and classical music.

Because the survey interviewed the Dutch students over the course of three consecutive years, Delsing and his team could also consider the development of musical taste in light of personality. They discovered that young teens tended to change their preferences only slightly; as the kids got older, though, their opinions solidified. Extroverted teenagers often turned away from rock and punk with age, turning to pop and so-called urban styles. Of interest, the youth who listened to jazz and classical music often described themselves as emotionally unstable. In contrast, the college-age jazz and classical fans in Gosling's sample did not score above average in measures of neuroticism. Delsing hypothesizes that it is a sign of emotional

liability for adolescents to listen to more sophisticated music, whereas it is entirely normal for older students.

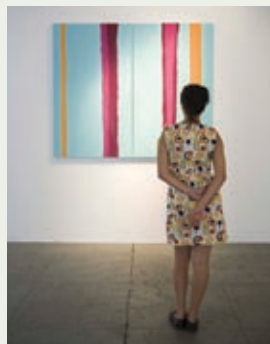
More recent studies have called Gosling and Rentfrow's musical profiles into question. In 2008 psychologist Hasan G. Tekman of Uludağ University in Bursa, Turkey, added a fifth musical style, Turkish folk music, to the mix. He found that Turkish folk fans typically scored high in agreeability, above average in conscientiousness and slightly above average in neuroticism. Furthermore, Tekman found very different associations between other musical styles and Big Five traits. For example, among the Turkish sample, people who liked reflective and complex styles of music were not generally open—as was the case in the American and Dutch samples. Also in 2008 a German survey of musical tastes among 422 students at the University of the Bundeswehr in Munich failed to match Gosling and Rentfrow's results.

“The four dimensions they [Gosling and Rentfrow] established in their 2003 study provide a broad look at some of the relationships between music preferences and personality,” says Richard L. Zweigenhaft of Guilford College, but his own findings “indicate that it is important to examine specific music genres.” Among 83 students, he uncovered a number of statistically significant associations: radio listeners tended to be less fearful but also less orderly, dutiful or disciplined than average Americans; opera and heavy metal fans both tended to be disorderly; and those who liked rap and hip-hop claimed to lack self-discipline and sincerity but also described themselves as impulsive, open and sociable. And as with Delsing, Zweigenhaft showed that not all fans of religious music are alike.

### Novelty Seeker?

People with a high degree of openness to new experiences tend to share these six characteristics:

- Strong imagination and lively fantasy life
- Varied interests in art, music and literature
- Appreciation of emotional experiences
- Intellectual curiosity
- Ability to enjoy new activities and places
- Readiness to question previously held values and norms



### Trills and Chills

As these studies show, not all aficionados are created equal, but many music fans have more in common than just a list of favorite songs. In 2007 Adrian C. North of Heriot Watt University in Edinburgh and David J. Hargreaves of Roehampton University in London surveyed more than 2,500 Britons between the ages of 18 and 60 about their choices in music and lifestyle. They found that lovers of musicals tended to lead exemplary lives: they avoided alcohol and drugs, obeyed laws and gave to charity. Connoisseurs of classical music, jazz, blues and opera

were among the best educated in the sample, and hip-hop and dance-floor listeners were more prone to use drugs. In 2009 Juul Mulder of Utrecht and her colleagues mined similar patterns from a Dutch study of 7,000-plus teens: fans of punk, hardcore, techno and reggae used more drugs than fans of mainstream, pop or classical music. They only did so, though, if they had contact with other fans who used drugs.

Sensation seeking—a trait that is thought to be 50 percent inherited—may be the common denominator that links some music subcultures to recreational drugs. More conservative people simply do not need to take the same kinds of musical, or medical, risks to achieve the same emotional highs. Personality may also help explain why one song can move one person to get up and dance but not another. For the average listener, the regularity of pop suffices. Sensation seekers, however, might physically need more stimulation—in the form of a wailing guitar riff or powerful beat—to feel chills down their spine and tingling in their toes. By the same token, people who are open to new experiences may require more challenging melodies or complicated rhythms to get their groove on.

What exactly creates these musical highs? A number of scientists are exploring our emotional and physiological response to music. In 2009 neuropsychologist Valorie N. Salimpoor and her colleagues at McGill University asked 26 subjects to listen to two types of music, favorite pieces and songs toward which they felt neutral. As expected, the high feelings the participants experienced during favorite songs appeared to result from autonomic stimulation: moments of musical bliss were associated with increases in skin conductivity, respiratory rate and heart rate, as well as drops in blood pressure and body temperature. Similar responses did not occur when the participants listened to songs they did not especially like.

In 2005 neuroscientists Daniel J. Levitin, also at McGill, and Vinod Menon of Stanford University reported that musical enjoyment changes the activity in a neuronal network involved in other positive emotions. In particular, the ventral tegmental area, a collection of cells in the midbrain that are central to our reward circuitry, alters the interactions among three structures—the nucleus accumbens, the hypothalamus and the insula—that regulate autonomic arousal. In 2002 Eckart Altenmüller, director of the Institute for Music Physiology at the University of Hannover in Germany, showed that musical enjoyment also coincides with greater activity in the left cortex—a region other studies have linked to positive emotions in general. He further found an association between negative feelings about music and increased firings in the right cortex.

Harmony—or at least a lack thereof—seems to account for some of our emotional response to music. In 1999 neuropsychologist Anne J. Blood, now at Harvard University, worked with her colleagues at McGill to compose six musical varia-

## Sensation Seeking— Looking for Kicks

The insatiable hunger for stimulation has four facets:

- Tendency to be bored
- Desire for change
- Desire for thrills
- An uninhibited lifestyle



tions, ranging from harmonious to cacophonous, and played them for a group of 10 test subjects. The more dissonant the melody, the less the subjects liked it. Moreover, PET scans revealed that listening to dissonant tunes coincided with greater blood flow in certain regions of the right hemisphere. In another study, Blood showed that the thrill we get from a favorite song activates the same ventral limbic structures that are engaged when we eat chocolate.

To date, no studies have explored how we react biologically to art or music in light of personality or why we enjoy cultural productions in the first place. And researchers in this field are challenged by the fact that the arts are a moving target: what begins as cultural rebellion quickly becomes mainstream. The Rolling Stones and pop art may have gotten a rise from sensation seekers in the 1960s, but they probably would not pique a new generation of rebels raised on Lady Gaga and Damien Hirst. So the next time you go judging your friend's new roommate, ask for his age: if that old pile of punk records in the corner belonged to his dad, he may not be up for lots of loud parties. **M**

## (Further Reading)

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# WHERE ARE THE TALKING ROBOTS?

Teaching a machine to speak has been a dream for decades. First we have to figure out how we know what we know about language

*By Joshua K. Hartshorne*

**S**ulla, the world's first talking robot, was so adept at conversation—in four languages, no less—that a human visitor to the laboratory in which she was created refused to believe she was not a real person.

Alas, Sulla was not a real robot, either, but a character in Karel Čapek's 1921 play *R.U.R.*, which introduced the word “robot” to the lexicon. Ever since that debut, talking robots have seemed to be peeking around every corner, and not just in science fiction.

Almost as soon as modern computers were invented, researchers began to think about programming them to use language. In 1950 Alan M. Turing, one of the founders of computer science, predicted that by the turn of the century machines would be able to speak English so fluently that it would be difficult to tell a person from a machine—an achievement later dubbed the Turing test. Four years later a coalition of scientists at Georgetown University and IBM unveiled the 701 translation machine, which successfully translated 60 Rus-

sian sentences to English at the rate of two and a half lines per second, leading Leon Dostert, the researcher who dreamed up the technique used by the machine, to report confidently that fluent electronic translators were only “five, perhaps three years” off.

We are waiting still. After wave upon wave of optimistic prognoses followed by dismal failures, full-fledged talking robots seem no closer than other midcentury fantasies such as underwater cities and Martian colonies. If anything, the yearning for talking ro-



LOUIE PSIHUYOS Getty Images



# OUR ABILITY TO SOLVE TASKS THAT WOULD SEEM TO BE AS DISCERNING THE MEANING OF SINGLE WORDS—IS IN OF EVOLUTION. INDEED, WE ACCOMPLISH SUCH TASKS

**Primed to speak:** Research suggests that people quickly home in on the correct meaning of ambiguous words such as “bank” by taking cues from surrounding words: “swam” indicates the side of a river; “check,” a financial institution.



bots is even more intense today because of our wish to replace the keyboard as our interface with digital services and ever smaller electronic devices.

Recent work in artificial speech has brought mixed results, giving us machines that can comprehend enough language to be useful (examples: Google Translate and the automated voice that answers your calls to customer service) while also confronting us with the limitations of the technology and its susceptibility to catastrophic failure (examples: Google Translate and the automated voice that answers your calls to customer service). Other projects are attempting to address these shortcomings by enlisting public participation via the Web so that we might learn more about how we choose our words.

But technology is not the only problem or even the biggest one: language has proved harder to understand than anyone had imagined. Our ability to perform such tasks as choosing the correct meaning of ambiguous words is in fact the fruit of millions

of years of evolution. And we accomplish these feats without knowing how we do so, much less how to teach the skill to an artificial being. Indeed, as scientists try to codify grammar and tease out the subtle distinctions between similar terms, they are learning that meaning can be elusive and that the structure of language is a mystery even to we humans who have mastered it.

## Old Rules, Broken

The earliest attempt to create talking robots was deceptively simple: to program them with the rules of grammar. This was IBM’s strategy with its 701 machine, which was directed to translate Russian texts in its first public performance because of cold war interest in the Soviets. The 1954 press release introducing the project explains how the machine dealt with such language differences as word order. For instance, the English translation of the Russian *gyeneral mayor* is “major general.” Whenever the machine encountered the Russian word *mayor*, its programming checked the previous word. If it was *gyeneral*, the 701 changed the order of the two words when it generated the English translation.

That such a straightforward system worked at all was partly because the 701 knew only 250 Russian words, so programming the machine to recognize every pair of adjectives and nouns in its database was not an onerous job. But many languages have hundreds of thousands of words, and English may have more than a million. If we make the reasonable assumption that half the words in English have multiple meanings, the programmer must consider 500 billion word pairs. At one word pair per second, writing the program would take nearly 16,000 years.

### FAST FACTS

#### That Does Not Compute

- 1>> Programming a robot with the rules of English is difficult because we still do not know what all the rules are.
- 2>> To help robots sort out ambiguity, scientists build language machines by feeding them billions of words tagged for meaning and parts of speech.
- 3>> Researchers are using crowdsourcing on the Web to give robots a better sense of how human beings interpret and use language.

GILDO NICOLO SPADONI/Graphistock/Corbis (left); SAM CHRYSANTHOU/All Canada Photos/Corbis (right)



# COMPARATIVELY STRAIGHTFORWARD—SUCH FACT THE FRUIT OF MILLIONS OF YEARS WITHOUT KNOWING HOW WE DO SO.



As it happens, the phrase *gyeneral mayor* is actually an aberration—word order in Russian is generally similar to that in English, as opposed to, say, Spanish, where adjectives generally follow nouns. An apparent solution for a machine with a bigger vocabulary would be to program it with a rule such as “adjectives come before nouns in English and Russian but after nouns in Spanish” and append a list of rules for the exceptions. This strategy would not only vastly reduce the number of rules but also allow the system to handle new words. The problem is that the rules explaining the exceptions are likely to have exceptions, too. Although publishers of grammar books are loath to admit as much, scientists still have not found a set of abstract rules that fully explain English, Russian or any other language.

Yet the fragility of these systems lies not just in the imperfectibility of grammatical rules but also in the complexity of tasks as misleadingly straightforward as perceiving the meanings of single words.

## Words of Many Meanings

One of the first problems encountered by a talking robot (and a talking robot’s engineer) is that many of the words we use in everyday speech are homophones: they have multiple meanings. “Bank” can refer to either a financial institution (“John cashed a check at the bank”) or the side of a river (“John swam to the nearest bank”).

People quickly home in on the correct meaning when faced with such sentences. Psycholinguists Cyma van Petten and Marta Kutas of the University of California, San Diego, demonstrated this aptitude in a well-known 1987 paper about lexical priming—encountering a word primes people to process other words with related meanings. They found that just more than half a second after people come upon a homophone like “bank,” only words related to the contextually appropriate meaning were still primed (“money” in sentence one above and “river” in sentence two).

This signature of normal processing breaks down in certain populations. In 2002 a team of neuroscientists led by Tatiana Sitnikova of Tufts University found that individuals who have schizophrenia fail to suppress the contextually inappropriate meaning of an ambiguous word: both “home

run” and “vampire” were still primed more than a second after encountering “bat.”

This work, though, tells us only that most people quickly resolve homophones by using context. The problem for the talking robot’s engineer is that we do not know precisely how we do so.

One theory is that we make use of the words surrounding the homophone. Discussions of financial institutions usually include words such as “check” and “cashed,” whereas discussions of river edges include words such as “swam” and “water.” We may simply have learned, in general, that certain words predict one meaning of “bank” and other words predict the other.

Even trickier to sort out than homophones are their cousins, polysemous words. Like homophones, polysemes have multiple meanings, but the meanings are closely related. Compare the two senses of “Jane Austen” in “Jane Austen wrote many books” and “I read some Jane Austen this afternoon.” In the first sentence, the name refers to the author; in the second, to her work. Indeed, polysemy applies not only to all authors but also to all kinds of media. Rupert Murdoch has bought the *Wall Street Journal* (the company), and so have I (an individual issue).

Once again, context clearly matters, but the distinctions are subtle and difficult to define. Although the two senses of “bank” rarely appear in the same sentence, “Jane Austen” often appears in the same sentence as “*Pride and Prejudice*” whether the name refers to the person or her writing, so simple recourse to the surrounding words does not always work. How people discern the correct meaning is still not entirely clear.

Words such as “bank” and “Jane Austen” present a problem because they have several meanings. Pity the poor robot that has to sort out pronouns, which can have an almost limitless number of

## (The Author)

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**Found in translation:** Scientists create language machines by feeding them huge bodies of text called corpora. Google Translate bulked up on a diet of United Nations documents that had already been translated into a variety of languages, helping resolve ambiguities.

meanings. In the sentence “I wrote *Pride and Prejudice*,” the pronoun “I” refers to Jane Austen as long as it is Jane Austen who is talking. If the speaker is an actor playing Jane Austen (such as Anne Hathaway in *Becoming Jane*), then “I” refers not to the speaker but to the person she is playing. There is no simple rule. Third-person pronouns are even worse. In “She wrote *Pride and Prejudice*,” the pronoun can refer to just about anyone female regardless of who is speaking. The robot cannot simply ignore these ambiguities, because without knowing who the sentence is about, the sentence hardly means anything at all.

Perhaps the best-known model for resolving the pronoun conundrum is Centering Theory. Developed during the 1980s and 1990s by computer scientist Barbara Grosz of Harvard University and computer scientist Aravind K. Joshi and philosopher Scott Weinstein of the University of Pennsylvania, the theory comprehensively accounts for how sentences fit together in a broader discourse. It predicts that people use pronouns such as “she” to refer to the center—or most salient character—from the previous sentence, typically its subject. This prediction explains why people usually use “she” to refer to Jane Austen in the sentences “Jane Austen was an author. She wrote *Pride and Prejudice*.”

Unfortunately for our robot, matters are not always so simple. In her 1998 dissertation, psycholinguist Jennifer Arnold estimated that only 64 percent of subject pronouns refer to the previous

subject. Moreover, numerous studies going back to a seminal 1974 paper by linguist Catherine Garvey and neuroscientist Alfonso Caramazza of Johns Hopkins University have shown that the contextual cues for the human interpretation of pronouns can be maddeningly subtle. For instance, in work just submitted for publication, Harvard psychologist Jesse Snedeker and I reported that most people expect the pronoun in “Sally frightened Mary because she is strange” to refer to Sally but to Mary in “Sally feared Mary because she is strange.” How people make these decisions remains unknown, but they do so rapidly. In 2007 a research team led by psycholinguist Jos van Berkum of the University of Amsterdam asked people to read sentences that did or did not follow the expected pattern, such as “Sally frightened John because she/he is strange,” while their brain waves were monitored. The brain waves showed a telltale signature of extra processing when the pronoun did not match the overall sentence bias (“he” instead of “she” in the sentence above).

### Bodies of Language

Given the bewildering nuances of words, scientists need to find ways to help robots make better predictions. Many have turned to the statistics of language, loading up their word machines with gobs of raw material and then working the numbers. They first feed their machines a huge collection of texts called a corpus—sometimes surpassing a billion words. The machine then breaks up the text into segments of  $n$  consecutive words, called  $n$ -grams. By looking at all the  $n$ -grams it has ingested, the machine learns which words tend to go with which other words. It comes to know, for instance, that the phrase “tall man” is fairly common in English (1,320,000 Google hits) and “man tall” is relatively rare (205,000 hits). Similarly, the machine might learn that in the majority of sentences in which “bank” is preceded by “swam,” it means “river edge.” The 701 actually worked with  $n$ -grams (more specifically, two-word bigrams).

Statistical systems have significant advantages because the programmer does not need to formulate explicit rules such as “‘general’ comes before ‘major’” or even abstract rules such as “adjectives



GIVEN THE BEWILDERING **NUANCES OF WORDS**, **BETTER PREDICTIONS**. MANY HAVE TURNED **WORD MACHINES WITH GOBS OF RAW MATERIAL**

EMILE WAMSTEKER AP Photo (United Nations); PHIL BRAY Touchstone/The Kobal Collection (Bicentennial Man)

## Chatty Programs

A fixture of the artificial-intelligence world since the late 1960s, chatbots are computer programs that simulate conversations. The original program, ELIZA, could handle just a few topics. When it encountered a sentence it did not understand, it replied with a question (“Why do you say that...?”) or dodged the topic entirely (“My head hurts”). Modern chatbots are considerably more sophisticated. Here is an excerpt from a conversation with Elbot (www.elbot.com), the winner of the 2008 Loebner Prize, a competition for chatbots:



HAL, from the Stanley Kubrick film *2001: A Space Odyssey*, was a chatbot of sorts with a malevolent streak.

which assigns the appropriate emotion for each situation.

**HARTSHORNE:** So how are you feeling now?

**ELBOT:** At this time, I am feeling inconsiderate.

Elbot clearly can sometimes produce natural conversations and certainly represents a considerable improvement since the original ELIZA. Elbot's speech is still riddled with non sequi-

turs, though, and even the occasional grammatical error:

**ELBOT:** Hi! I'm Elbot. I promise I won't blog about anything you tell me during this conversation.

**HARTSHORNE:** That's fine. I'm actually writing about this conversation for *Scientific American Mind*.

**ELBOT:** The inside of my head is plated with asbestos. Nothing gets out.

**HARTSHORNE:** I know the feeling.

**ELBOT:** My moods are controlled by an emotion processor

**HARTSHORNE:** Did you see the Red Sox game today?

**ELBOT:** I'm not sure I ever saw that. I'm not even sure you can use in that context.

Elbot probably parsed my question as: Did you see + NOUN PHRASE. “I'm not sure I ever saw that” would have been a fine reply if I had asked about a movie. To get this conversation right, Elbot has to know what a Red Sox game is. Generating meaningful language requires more than a few rules of grammar. —J.H.

come before nouns.” Statistical systems simply learn which words come before which other words. More complex implementations track information such as parts of speech, too, helping language machines learn that “check” is a better predictor of “financial institution” when used as a noun rather than as a verb.

Research also suggests that statistical learning—the ability to recognize patterns in the environment—may help humans absorb language, making the method particularly appealing to robot designers. A 1996 study by psychologists Jenny Saffran, Richard Aslin and Elissa Newport of the University of Rochester showed that even eight-month-old infants could learn trigram probabilities—the likelihood of trios of words or syllables to appear in sequence. The researchers had infants listen to strings of nonsense syllables like *bidakupadotigolabi*. The trigrams *bidaku*,

*padoti* and *golabi* were all very common; others, including *dakupa*, were much less so. After hearing these nonsense strings for two minutes, the babies could tell the difference between the common and uncommon trigrams (they listened longer to the rarer ones, as if they were new); the authors interpreted the aptitude as evidence that children could learn word boundaries in this fashion. Similarly, in 2010 a team led by psychologist Christopher Conway of Saint Louis University found that people who are better at statistical learning are also better at making out speech under noisy conditions.

Although *n*-gram machines are not the only type of language system that scientists are trying out, engineers like using them because getting hold of large corpora is easy. Google, for instance, has published a Web corpus with more than a trillion words. But for corpora to sort out the subtleties of word mean-

SCIENTISTS NEED TO FIND WAYS TO **HELP ROBOTS MAKE** TO THE STATISTICS OF LANGUAGE, **LOADING UP THEIR** AND THEN WORKING THE NUMBERS.

# RECOURSE TO SURROUNDING WORDS WOULD NEVER EXPLAIN BOX WAS IN THE PEN” MUST REFER TO AN ENCLOSURE, NOT A INSTEAD FROM OUR KNOWLEDGE THAT BOXES DO NOT FIT

ing and pronoun reference, the sentences must be tagged—that is, labeled with the definition or the part of speech of each word—and most basic corpora are not. The largest corpus tagged for meaning is SemCor (short for semantic correlation). Created at Princeton University, SemCor contains 360,000 words. That is a very large corpus measured by the effort needed to label all those words, but small for the purposes of the talking robot’s engineer.

We can get a sense of the ensuing strengths and weaknesses of  $n$ -gram machines by looking at a pair of such systems developed by Google. One, a statistical translator called Google Translate, is fed a diet of documents that have already been translated into a variety of languages. (Google Translate’s original fodder consisted largely of United Nations documents, which are issued in multiple languages.) Because a homophone in one language is typically represented by two words in another (“bank” is *orilla* and *banco* in Spanish), the bilingual corpora used to train statistical translation machines can stand in for a meaning-tagged corpus. The translator can learn to distinguish sen-

tences containing “bank” in English and *orilla* in Spanish (most likely sentences with the word “swim”) from those containing “bank” in English and *banco* in Spanish (sentences with the words “cashed” and “check”).

Google Scribe—a tool that predicts your next word as you type—is another variant of the  $n$ -gram machine designed to help generate sentences. Type “major,” and it predicts the following: “role,” “cities,” “and,” “role in,” “problem,” “histocompatibility complex,” “league.” All these are common combinations (even “major histocompatibility complex,” which has more than a million Google hits).

This abundance of possibilities points to a principal limitation of today’s  $n$ -gram machines. Because they track contexts only a few words long, they break down if there is too much room between relevant words. Type in “He swam to the bank,” and Google Translate returns *Él nadó hasta la orilla*, which is correct. Try “He swam to the nearest bank,” though, and you get *Él nadó hasta el banco más cercano*, which means “He swam to the nearest financial institution.” Bilingual corpora are also little help in sorting out polysemous words and pronouns. Many words that are polysemes in one language are polysemes in others.

Similarly, Google Scribe and other simple  $n$ -gram machines can neither handle new words nor generate useful sentences. Even young children can use new words in sentences, but Google Scribe makes no suggestions after you type in the coinage “wug.” And because it learns the statistics only of short phrases, the sentences it produces are coherent word by word but ramble on nonsensically. For instance, type “Google” into Google Scribe and select the first suggestion it gives after each word, and you end up with “Google Scholar search results on terms that are relevant to the topic of the Large Hadron Collider at the European level and the other is a more detailed description of the invention.” Such  $n$ -gram systems simply cannot relate the beginning of a sentence to the end.

## Inching toward Talking Robots

One of the simplest ways to improve  $n$ -gram machines would be to have them use longer sequences. This task is more difficult than it sounds. Assume a

**A sea of meaning:** Pity the robot that has to sort out pronouns. Words like “he” and “she” can indicate just about any person of the correct gender. Pronouns usually refer to the subject of the previous sentence, but only about two thirds of the time.



MOODBOARD/CORBIS

# HOW PEOPLE KNOW THAT “PEN” IN “THE WRITING DEVICE; THE INFERENCE SPRINGS INSIDE WRITING DEVICES.



language contains only 10,000 words. To include every possible trigram, a word machine would have to learn a trillion combinations—10,000 to the third power. Storing every possible six-word sequence (still not long enough to do the job) would require  $10^{24}$  combinations—about 10 trillion exabytes of information. All the digital information on planet Earth was reckoned in 2009 at only 500 exabytes.

But even if it had the backing of a gargantuan corpus tagged for meaning, the apt robot pupil would still need to absorb some street smarts before it could speak with authority. In a classic 1960 paper philosopher Yehoshua Bar-Hillel of Hebrew University argued that recourse to surrounding words would never explain how people know that “pen” in “the box was in the pen” must refer to an enclosure, not a writing device; the inference springs not from the context but from our knowledge that boxes do not fit inside writing devices.

To help give robots the benefit of real-world experience while bridging the data gap, several recent Web-based projects have sought to enlist the public. Computer scientists at Carnegie Mellon University, led by Anthony Tomasic, will soon launch an Internet game called Jinx. Two players are presented with a word in the context of a sentence (for instance, “John cashed a check at the BANK”) and are asked to type related words as quickly as possible. They win points if they both come up with the same word. The researchers can use these guesses, particularly when the players agree, to label the meanings of the ambiguous words, creating a tagged corpus larger than SemCor.

My own Pronoun Sleuth ([gameswithwords.org/PronounSleuth](http://gameswithwords.org/PronounSleuth)) is a Web site that asks volunteers to read sentences containing pronouns and decide to whom the pronoun refers, as in “Sally went to the store with Mary. She bought ice cream.” For some sentences, agreement among the players is fairly strong; in others, less so. We have found that to distinguish one kind of sentence from the other, we need data from 30 to 40 people. At last count, more than 5,000 participants have judged several sentences apiece. Snedeker and I recently submitted a paper that had data for 1,000 sentences—a small number relative to what robots would need to sort out pronoun nuances, but it is by far the largest da-

tabase of such sentences that is currently available.

Phrase Detectives ([anawiki.essex.ac.uk/phrasedetectives](http://anawiki.essex.ac.uk/phrasedetectives)), created in 2008 by computer scientists at the University of Essex in England, takes a more traditional approach, presenting players with a section of a book or article. When participants come across a pronoun, they are asked to identify the word to which the pronoun refers. Phrase Detectives also asks players about other referential expressions. The experimenters are interested, for instance, if players recognize that in the passage “Jane Austen wrote *Pride and Prejudice*. The book was very popular,” “the book” refers to *Pride and Prejudice*. Thus far players of Phrase Detectives have completed work on 317 documents. Collectively, data from projects such as these will enable us to build and test theories that may lead one day to pronoun-using robots.

When, though, is an open question, and our expectations may be as unrealistic as ever. Despite understanding the obstacles, Franz Joseph Och, head of Google’s machine-translation group, said in a recent interview with the *Los Angeles Times* that instantaneous speech-to-speech translation à la *Star Trek*’s universal translator should be possible “in the not too distant future.” But building a talking robot will require understanding the secrets of language itself, which may prove just as elusive as anything else on *Star Trek*. **M**

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# Ruled by the **BODY**

Many common ailments and physical conditions can influence the brain, leaving you depressed, anxious or slow-witted

By **Erich Kasten**

**W**hen I first met Tina, a woman in her late 20s, she had been seeing mental health professionals for virtually her entire life. “One day I’m energetic and creative,” she told me during one of our therapy sessions, “the next I am aimless, or I cry and feel worthless.” Tina had been diagnosed with depression, borderline personality disorder and even schizophrenia. Doctors prescribed antidepressants and later antipsychotics—but the meds only seemed to make her

worse. At first I, too, saw her difficulties through the lens of a psychologist, thinking she had bipolar disorder. But later I noticed that her mood swings were accompanied by symptoms such as a racing heart, nausea and joint pain. So I asked her doctors to do a thorough blood workup.

Finally, after her 30th birthday, a doctor discovered the real cause of her suffering: porphyria, a group of rare genetic metabolic disorders. In people with porphyria, precursors of hemoglobin (the molecule that carries oxygen in red blood cells) called porphyrins accumu-

late in various body systems, causing symptoms from abdominal pain to depression. The female sex hormone progesterone tends to aggravate the condition, so Tina’s moods followed her menstrual cycle. Because the disorder affects the liver, the body has difficulty processing medication, so drugs often create perplexing new symptoms.

Porphyria is rare, but its effects on mental well-being provide an example of a far more widespread, though similarly unrecognized, notion: many physical ailments can surreptitiously erode the psyche. For example, inflammation

from infections and chronic disorders can spawn depression. Sadness and lethargy may also result from hormone imbalances or nutrient deficiencies. Anxiety symptoms can be a sign of allergies or an overactive thyroid gland. And something as simple as a lack of water or iron can impair the ability to learn, remember and plan.

Doctors often forget to ask patients about psychological symptoms. Conversely, psychologists and psychiatrists may treat mental troubles in isolation without looking for a physical cause. But now some doctors and psychologists are reviving the decades-old discipline of somatopsychology, which centers on the effects of physical illness on the brain.

## **Infectious Moods**

In Western culture people have long treated body and mind as separate. This dichotomy, popularized by French philosopher René Descartes in the 17th century, is still reflected in medical practice, as the specialists who look after our bodies re-

main different from those who attend to our psyches. Of course, the division has blurred in recent decades. We now know, after all, that the mind is housed in a physical entity, the brain, which is part of the body. And most people are also aware that psychological problems can produce

fail because the root of the problem lies in the body—and in particular the immune system.

Your body's defenses affect the brain, in large part, through immune signaling molecules called cytokines. These substances cross the blood-brain

Melbourne in Australia found evidence that chronic inflammation raises a person's risk of acquiring depression and may be a cause of this mental disorder. The researchers followed 644 mentally healthy women from 20 to 84 years old for a decade, periodically measuring

**Although you no longer feel sick, your immune system's continued vigilance can keep you in low spirits for weeks and months.**

physical symptoms in the form of psychosomatics; for instance, mental stress can spawn headaches, an upset stomach or even heart problems.

But fewer people appreciate that the influence also runs in the other direction—that changes in your body can profoundly perturb your mental state. These changes can range from rare maladies such as Tina's to the common cold. Although German psychiatrist Karl Jaspers coined the word "somatopsychology" back in 1923, the discipline is still somewhat obscure; a search for the term on PubMed brings up only four papers on the topic. Nevertheless, the data linking specific bodily ailments to psychiatric troubles are far more prevalent, especially in the case of depression.

If you have been feeling tired, low and adrift from your friends—and cannot shake your bad mood—you may have symptoms of depression. Although psychiatric drugs and counseling are the standard remedies, they do not always work. In some cases, these treatments

barrier and bind to receptors on neurons in brain structures that govern emotions. The brain cells respond by unleashing substances called neuropeptides, which produce fatigue, lowered concentration and social withdrawal.

As a result, when you are fighting a cold, for example, symptoms such as a runny nose and sore throat are accompanied by a feeling of exhaustion and a desire to be alone, reactions that stem from the brain and serve to inhibit physical activity. When inflammation becomes chronic—say, after bacteria entrench themselves inside isolated pockets of the body, such as the tonsils and sinuses—so can your bad mood. Safe from immune system attacks in these locations, the pathogens proliferate and spread out through the body at a slow but steady rate. Although you no longer feel sick, your immune system's continued vigilance can keep you in low spirits for weeks and months.

In 2010 epidemiologist Julie Pasco and her colleagues at the University of



**COLD COMFORT:** When you are fighting a cold, you feel tired and act introverted because the immune reaction affects the brain.

their blood levels of C-reactive protein (CRP), a marker for low-grade inflammation, and assessing them for symptoms of depression. They found that the risk of depression (which 48 of the women developed) increased with CRP concentration, even after adjusting for various lifestyle factors and illnesses.

Other studies have shown that people with a diagnosis of depression or bipolar disorder tend to exhibit higher levels of inflammation than people without mental illness. In addition, the depressed patients most likely to show signs of persistent inflammation are those who have been most resistant to antidepressants and talk therapy. What is more, inhibiting inflammatory cytokines seems to help relieve the

#### FAST FACTS

#### Psychic Connection

- 1>> Many common sicknesses can affect the mind. Specialists are reviving the decades-old discipline of somatopsychology, which centers on the effects of physical illness on the brain.
- 2>> Inflammation, hormone imbalances or nutrient deficiencies can cause depression.
- 3>> A simple lack of water or iron can impair your ability to learn, remember and plan.





blues in these cases, research suggests.

A newly identified player in this process is an enzyme called IDO that is elevated in inflammatory disorders such as type 2 diabetes and rheumatoid arthritis. In 2009 immunophysiologist Keith Kelley and his colleagues at the University of Illinois induced low-grade chronic inflammation in mice by giving them tuberculosis vaccine. The injection boosted IDO levels in their brains, presumably a result of the actions of cytokines. The mice got sick, but even after they recovered they showed signs of rodent depression: placed in a bucket of water, they made little effort to escape. The behavior of the mice vastly improved, however, after the researchers gave them a drug that blocked IDO, indicating that the enzyme is a critical link between inflammation and sour mood. [For more on infections that wreak havoc on the brain, especially during development, see “Infected with Insanity,” by Melinda Wenner; SCIENTIFIC AMERICAN MIND, April/May 2008.]

### Hormone Havoc

Bad moods can also arise from changes in hormones, signaling molecules that circulate in the blood. Compared with the electrical and chemical signals neurons send to one another, hormones act

more slowly, but their influence on the body and brain endures for longer periods, exerting psychological effects through specialized receptors on brain cells involved in regulating emotions.

If you are a man older than 40 and you feel tired, unmotivated, irritable and down, your “midlife crisis” could stem from lack of the hormone testosterone, which declines slowly but steadily with age. This hormonal drop is associated not only with physical symptoms such as erectile dysfunction and muscle weakness but also with lasting self-doubt and depression.

Fluctuating hormone levels may also precipitate moodiness in women approaching menopause. A drop in the hormone estrogen, in particular, can lead to bouts of sadness and hopelessness or, in some cases, clinical depression. A rise in progesterone and a dip in estrogen toward the end of the menstrual cycle are also thought to underlie premenstrual syndrome, an array of physical and psychological symptoms, including depressed mood, that many women experience just prior to their periods.

In some people, fatigue and bad moods, especially if accompanied by weight gain, are signs of an underactive thyroid, a gland in the neck that controls

**SORROW IN THE BLOOD:** Depression can originate in body organs other than the brain. Declining blood levels of testosterone can be a cause in men older than 40.

metabolic rate through its own suite of hormones. Hypothyroidism affects about 1 percent of people, leading to significant physical and mental distress. In a 2010 study physician Rolf Larisch and his colleagues at Heinrich Heine University in Germany gave 254 patients with thyroid abnormalities a health questionnaire that identifies mood disturbances. They found that hypothyroid patients with physical symptoms scored above average on the screening test, suggesting that the condition erodes mental health. From statistical analysis of the results, the researchers concluded that hypothyroidism boosts a person’s risk of a mood disorder sevenfold.

In addition to hormonal changes, inadequate intake of several micronutrients, including folate, vitamin B<sub>12</sub>, calcium, iron and omega-3 fatty acids, can

### (The Author)

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## Inadequate intake of micronutrients such as folate, calcium, iron and omega-3 fatty acids can influence a person's mood.

influence a person's emotional state. Calcium in particular is essential to a healthy brain; nerve cells need it to create the electrical impulses they use to communicate with one another.

Nutrient deficiencies may also underlie some postpartum depression. One of the primary culprits may be the omega-3 fatty acids, molecules found most prominently in oily fishes such as salm-

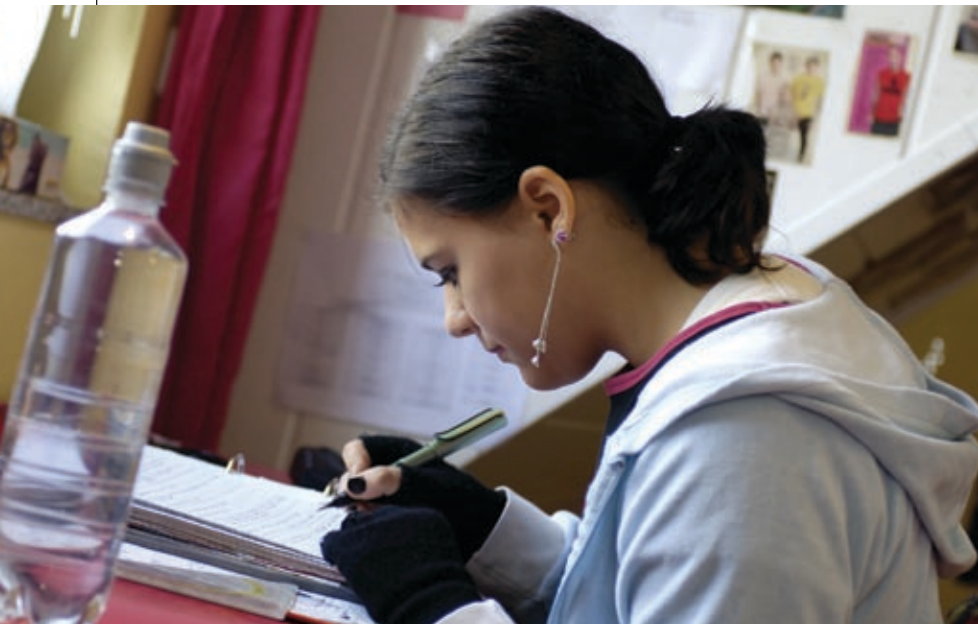
thought to be involved in depression, in the brain's frontal cortex.

Pregnant women eating a typical Western diet often fail to consume adequate amounts of these fatty acids, research suggests. In addition, many lack other nutrients that are important for emotional stability, such as folate, B vitamins, iron and calcium. [For more on postpartum depression, see "Misery in

these allergic reactions are mild enough to go unnoticed, and a person instead experiences splitting headaches, nausea and a racing heart, symptoms that are often mistaken for an anxiety disorder.

Hormone imbalances can make you anxious, too. For more than 20 years, a woman who would later become my patient suffered from mood swings, including attacks of rage and anxiety, that she was unable to control despite psychotherapy, meditation and relaxation techniques. She also felt constantly agitated and had trouble sleeping. Eventually her marriage fell apart. When she came to me for behavioral therapy, she had bulging eyeballs and a slight goiter (swelling of the thyroid gland in the neck). I recognized these as symptoms of a hyperactive thyroid; the gland was overproducing its hormones, which were elevated in her blood, thereby putting her metabolism into overdrive. Damage to the adrenal gland can render it unable to produce enough cortisol, which helps the body respond to stress. A lack of this hormone can result in signs suggestive of anxiety such as a racing heart, irritability and sweating.

Changes in your body can also erode your ability to think clearly. One common offender is a lack of water. Without enough of it, brain cells shrivel up, shrinking brain tissue and enlarging the spaces within the brain, called ventricles. The withered tissue is less able to efficiently process information. In young adults, research suggests, even mild dehydration leading to a loss of 2 to 3 percent of body weight can significantly impair cognitive capacities such as short-term memory, attention and ability to solve math problems. The danger may be greater in the elderly because older people often do not feel thirsty when they should, and insufficient fluids can lead to phases of forgetfulness, speech problems and confusion that relatives often mistake for dementia.



**JUST ADD WATER:** Take a drink when you need to think. Water is critical for cognition. Studies show that dehydration can impair memory, attention and problem-solving skills.

on, herring and sardines. Various studies, among them trials in which researchers manipulated the amount of these fats in women's diets, have linked low omega-3 levels to a higher incidence of maternal depression. In a 2011 review article, neuropharmacologist Beth Levant of the University of Kansas Medical Center described research explaining how a lack of omega-3 oils could bring on depression. In one study, researchers associated a diet-induced decrease in an omega-3 fatty acid called DHA in the brains of female rats with diminished levels of serotonin, a neurotransmitter

Motherhood," by Katja Gaschler; *SCIENTIFIC AMERICAN MIND*, February/March 2008.]

### Smart Water

Depression's close cousin, anxiety, can also have a physical basis. Allergies are among the more surprising causes of such distress and are all the more likely if your nervousness is seasonal. Microscopic arachnids known as house-dust mites are a common source of such covert allergies. When inhaled by a sensitive person, proteins in the mite feces often cause asthma and a runny nose. But sometimes



**IRON WILL?** About one in four pregnant women lacks iron, which is essential for mental sharpness and emotional stability.

A recent study suggests that your brain has to work harder when you are dehydrated. In 2010 psychiatrist Matthew J. Kempton and his colleagues at King's College London asked 10 healthy teenagers to lie inside a functional MRI machine while solving a puzzle, both while fully hydrated and after becoming parched from exercise. The teens did the task equally well under both conditions, but their brains had to exert greater effort in the dehydrated state: blood flow, a measure of neural activity, increased in the frontal and parietal (side) parts of the brain when the body lacked water. The frontal lobe in particular governs so-called executive functions such as planning and decision making. Thus, the researchers conclude, given the brain's limited resources, if a person fails to imbibe enough water over an extended period, his or her ability to plan and to process certain types of information is likely to suffer.

Even under ordinary conditions, just having a drink could help you think—at least if you are a kid. In a 2009 study psychologists Caroline J. Edmonds and Ben Jeffes of the University of East London found that giving mildly dehydrated six- and seven-year-olds a glass of water before a test im-

proved their scores. In another study of seven- to nine-year-olds, additional water similarly boosted performance in an assessment of visual attention.

### Inflammatory Thoughts

Cognitive troubles can stem from inflammation as well. In a 2010 investigation biological psychiatrist Clive Holmes of the University of Southampton in England and his colleagues found that patients with Alzheimer's disease who showed signs of chronic inflammation from disorders such as arthritis had four times as much memory loss over six months as patients without the additional immune reaction. Patients who also experienced short-term inflammation—say, from an infection—showed an even faster decline, probably because the excessive immune response killed brain cells, the researchers surmise. Surgery similarly spurs the immune system to action; it produces inflammation that leads to temporary mental fogging in 7 to 26 percent of patients who have had a recent operation.

Some vitamin and mineral deficiencies can impair cognition. In the developed world, about 10 percent of all women and one in four pregnant women are deficient in iron, which red blood cells need to carry oxygen. In a study published in 2007 nutrition researcher Laura Murray-Kolb, now at the Johns Hopkins Bloomberg School of Public Health, and her colleagues gave 113 young women a test of cognitive function and then put them on either iron supplements or dummy pills for 16 weeks. The lower a wom-

an's iron stores, the worse she performed on the initial test, the researchers found. In addition, the women who took the supplements improved markedly on a repeat test, demonstrating better attention, memory and learning, even though many had not been initially anemic. The results show that even mild deficiency can disrupt cognition and that boosting iron levels can make you smarter.

Seeing mental illness in the context of the entire body can thus help us see sources of distress that we might otherwise miss. In many cases, these bodily imbalances are easier to correct than ailments that originate in the brain itself. Vitamin and mineral deficiencies are relatively simple to rectify with supplements, although a doctor should advise you about the dose because some vitamins can be toxic in large amounts. One harmless remedy for cognitive lapses is drinking water, especially before tests or during tasks that require thought or concentration.

Other fixes may be more involved but nonetheless straightforward once a doctor has determined the cause of the problem. Thyroid or other metabolic disorders that spawn moodiness generally respond to standard therapies, as do hormonal deficits. Other cases of depression, especially those that have not been ameliorated by the usual remedies, may improve with drugs that target the immune system. In most instances, detecting and treating any such conditions require the advice of a doctor, although asking the right questions could improve the chances of a correct diagnosis—and a resolution of the problem. **M**

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# Your Avatar, Your Guide

**Seeing a digital doppelgänger can change your mind—for better or worse**

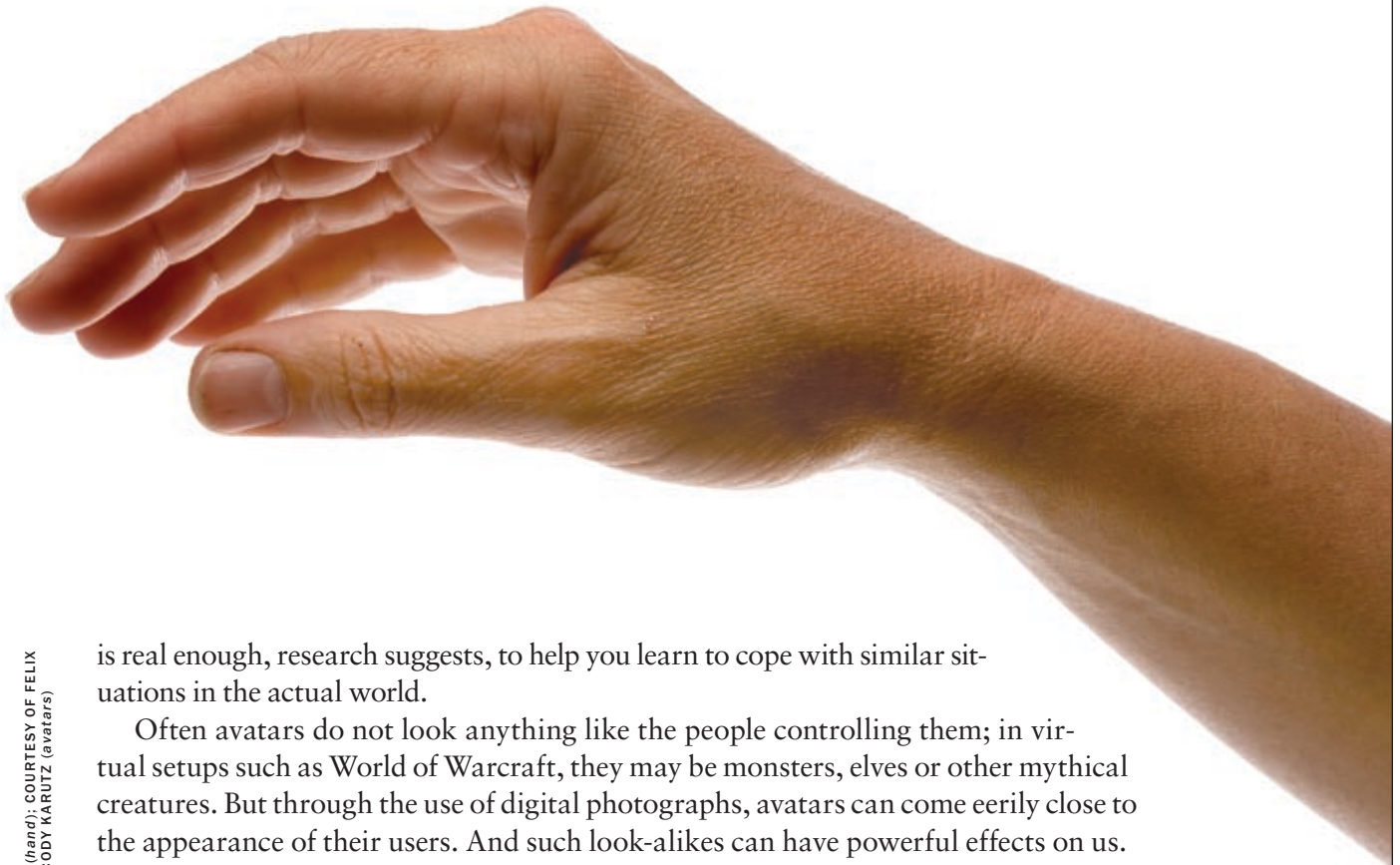
**By Samantha Murphy**

**Y**our favorite coffee shop is crowded with harried people, and you are standing shoulder to shoulder in a slow-moving line. Each jostling shift of the crowd aggravates your severe social anxiety. You start gasping for air; your heart quickens and you want to run.

But you force yourself to stay. You manage that feat only because you are not actually there. You are living this experience through your avatar, an animation that represents you in a virtual environment. In reality, you have never made it to the counter during the morning rush; instead you bolt out the door in a sweat. But you can get there on a computer. The experience of watching your digital look-alike uneventfully reach the front of the simulated line and order a pretend drink

VERONIKA SUROVTSEVA /iStockphoto

Researchers at Stanford University created a doppelgänger avatar (*right*) of an undergraduate lab assistant, Felix Chang (*left*). Chang also built a fantastical avatar (*center*) to represent him in the virtual-world Second Life.



is real enough, research suggests, to help you learn to cope with similar situations in the actual world.

Often avatars do not look anything like the people controlling them; in virtual setups such as World of Warcraft, they may be monsters, elves or other mythical creatures. But through the use of digital photographs, avatars can come eerily close to the appearance of their users. And such look-alikes can have powerful effects on us.

Recent studies have demonstrated that watching an avatar that resembles you can influence your thoughts, feelings and actions, often for the better—a phenomenon dubbed the “doppelgänger effect.” A mere three to five minutes of watching this digital representation of you—a kind of walking, talking photograph—can literally change your mind, improving your behavior in a social situation, calming your anxieties, swaying your views of a person or product, and helping you make better lifestyle or financial decisions.

CLAUDE DAGENAIS (Stockphoto (hand)); COURTESY OF FELIX CHANG (Chang); COURTESY OF CODY KARUTZ (avatars)



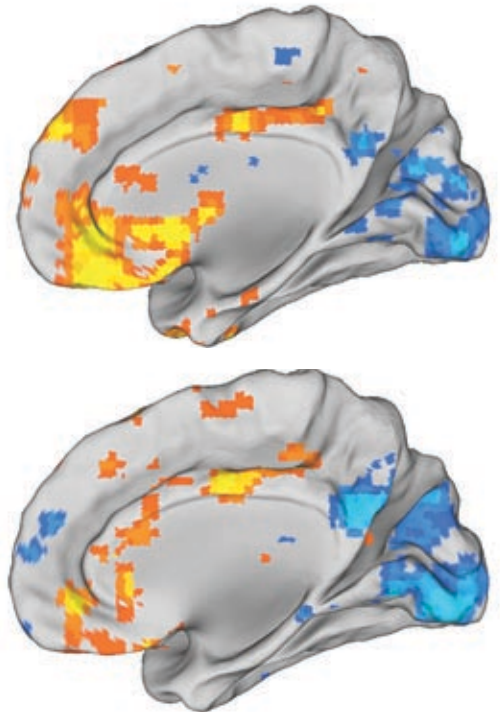
The author (top) fashioned a dark-haired female character to act on her behalf in the 3-D fantasy world *Second Life*.

### Living Virtually

History shows us precursors of today’s doppelgänger effect. For decades, if not centuries, educators and psychotherapists have used puppets and dolls to demonstrate appropriate or new behaviors to students and patients. Digital puppets—avatars, in other words—emerged in the early 1980s, when virtual personas appeared in television, movies and video games. Earlier in this decade, games such as *The Sims* and *Second Life* featured more realistic avatars that resembled people and could be customized.

Brain-imaging research suggests that people project themselves onto these avatars. In a study presented at the 2009 Society for Neuroscience meeting, social neuroscientist Kristina Caudle of Dartmouth College and her colleagues analyzed the brain activity of 15 hardcore gamers who spent an average of 23 hours a week as their avatars in *World of Warcraft*. When the gamers were given information about their avatars, their brains showed significantly more activity in a region called the medial prefrontal cortex [see illustration at right] than when they were thinking about people close to them, such as a best friend. The medial prefrontal cortex is concerned with processing high-priority “self-relevant” information. “This suggests that you’re recruiting similar parts of the brain when you’re thinking about the digital representation of yourself as you are when you’re thinking of the real-life version of yourself,” Caudle says. What is more, we remember information pertaining to ourselves better than we remember other types of data, which suggests that avatars can be a powerful learning tool.

Exposure to doppelgänger avatars, as opposed to the more fantastic kind, is likely to amplify this effect. According to a decades-old theory put forth by psychologist Albert Bandura of Stanford University,



When people think about themselves (top), they recruit brain regions similar to those activated when they process information about their avatars (bottom). Both situations elicit activity in the medial prefrontal cortex (lower left, yellow and orange), which is concerned with “self-relevant” information.

people learn from models, and the more the learner identifies with the model, the more effective the teaching. “These [doppelgänger] models work because they capitalize on something psychology has known for a long time,” says Jesse Fox, a communications researcher at Ohio State University.

Doppelgängers can be as simple as a flat, stationary, stone-faced cartoon picture or as complex as a three-dimensional, emoting and interacting projection. Rather than a cartoon tweaked until it sort of resembles you, this latter type of animated replica bears your visage. It is built by wrapping a digital photo of your face around a 3-D head and then attaching that construction to a generic male or female cartoon body.

### Digital Self-Help

Doppelgänger avatars allow you to see yourself perform a desired action, live out a fantasy or take on a slimmer, fatter or older form. For instance, they can help people to make smarter decisions about money. In a study currently in press, psychologist Hal Ersner-Hershfield, now at Northwestern University, and his colleagues created look-alike avatars of 50 participants whom they had digitally aged to 70 years old. Each user “inhabited” his or her avatar and peered

#### FAST FACTS

#### Animations on Our Minds

- 1>> Through the use of digital photographs, doppelgänger avatars can come eerily close to the looks of their users and in doing so exert powerful effects on them.
- 2>> Just three to five minutes of watching your digital double can improve your social skills, calm your anxieties and help you make better lifestyle or financial decisions.
- 3>> Doppelgänger avatars can imbue users with new preferences and false memories.

MANDY GETTER (Murphy); LINDEN LABS (avatar); KRISTINA CAUDLE Dartmouth College (brains)



Creating digitally aged avatars of individuals can give these people perspective, increasing the amount they save for retirement, for example.

out onto the virtual scenery from its perspective. Because of this viewpoint, researchers had some participants look in a virtual mirror to acquaint themselves with their senior selves while they answered questions known to enhance identification with an avatar, such as “What is your greatest fear?” and “What is your greatest hope?”

Participants were then told to allocate \$1,000 to four purposes: a special occasion, someone else, a short-term savings account and a retirement savings account. Those who had seen their older avatars opted to put twice as much into their retirement account as those who answered questions but did not see their aged selves. In a similar study published in 2006, exposure to senior counterparts lessened participants’ prejudices against older people, as assessed by a questionnaire, as compared with the attitudes of subjects who did not meet their digitally aged doppelgängers.

In addition to giving people perspective, doppelgänger avatars may be able to modify behavior by providing vicarious reinforcement. In a study published in 2009, Fox, then at Stanford, and her colleagues created avatar doubles for 69 college and graduate students who then watched their artificial selves eat in a virtual-reality environment. The avatar sat in front of a bowl of carrots and a bowl of chocolates. When the avatar ate chocolate, it got fat, and when it munched on carrots it slimmed down. Afterward, participants filled out a survey, which was placed next to a bowl of chocolates. The female participants who witnessed their avatars gaining and losing weight and felt immersed in the scenario consumed less of the available chocolate than did those whose avatars did not change or who did not buy into the virtual experience. Many of the women thought the visual reinforcement had altered their attitude and behavior. “Even though I really dislike carrots,” one said, “I liked watching my-

self get thinner, so watching the weight loss take place made me want to eat more healthily.”

On the other hand, men who felt immersed in the experiment ate more chocolate than did men who found the virtual environment lacking. Researchers are not sure how to explain this difference between men and women but suspect the effect

might be social: men who sit down to a meal with others tend to eat more than they do alone, whereas women who dine with company eat less. Participants seemed to be reacting to their doppelgängers as though they were dining with another person. Any incentive-based weight-loss avatar applications might have to address such subtleties. Nevertheless, Fox believes the technology is promising. “We got these effects from just three to five minutes of exposure,” she says.

“Who knows what would happen if people watched something like this every day?”

In a similar vein, avatar animations could motivate us to exercise. In another 2009 experiment by Fox’s team, students who saw themselves as avatars running on a treadmill and becoming increasingly fit-looking engaged in more physical activity in the next 24 hours than did those who saw their avatars standing still, looking bored. Students with the active avatars reported walking more blocks, climbing more stairs and hitting the gym more than did their control counterparts. “These are powerful persuasive models that can get us to change behaviors that we may even be resistant to changing,” Fox says, although she cannot yet say how long the effects of

People learn from models, and the more the learner identifies with the model the more effective the teaching.

### (The Author)

SAMANTHA MURPHY is a freelance writer living in Pennsylvania.

such interventions could last. Now she and her team are developing a program using photorealistic avatars that develop either benign moles or cancerous growths when exposed to the sun. It is designed to encourage users to protect their skin more reliably.

Psychologists and counselors have also begun using avatars to deliver therapy to clients who have phobias, a history of trauma, addictions, Asperger's syndrome or social anxiety. Indeed, almost a decade of research shows that virtual reality-based treatments are at least as effective as more traditional modalities, and "avatar therapy" is poised to be on the rise over the next few years. For instance, Stanford cognitive psychologist Jeremy Bailenson and psychiatrist Hoyle Leigh of the University of California, San Francisco, are studying the use of doppelgängers to teach people with schizophrenia, who have trouble making appropriate facial expressions, to smile. The program will show patients their avatar selves smiling in various situations.

Bailenson and psychologist Peter Mundy of the University of California, Davis, are also developing doppelgänger avatars that train people with Asperger's to make appropriate eye contact. When the subject embodies his or her avatar and looks into the eyes of another avatar, the avatar "friend" remains vivid. But when the subject's digital eyes look elsewhere, the other avatar starts fading away. By working to keep the other avatar visible (if only because that is the point of the game), patients will, the re-

searchers hope, learn to make and maintain eye contact in real life. Similar avatar programs could provide virtual social cues and stimulation to help people with social phobias (and those who are simply shy) gain courage to interact with others.

### Cartoons in Control

Avatars can also be used for less virtuous purposes, such as making us feel more favorably disposed toward a product or political candidate than we might otherwise be. Already commercials feature actors who look, sound and act like the people in the community they target, to get consumers to envision themselves as owners or users of a particular product. A doppelgänger avatar might be an even more powerful way to accomplish the same goal.

In 2010 researchers at Stanford's Virtual Human Interaction Lab decided to test the power of avatars to influence consumers. They asked 80 students to log on to a Web site and watch virtual endorsements of fictitious soft-drink brands. Some brands appeared on billboards with text endorsements only; others were shown with a picture of a stranger or a picture of the participant as a spokesperson [see illustration below]. In a survey asking which brand participants preferred, most chose the one that appeared with their own image. This finding suggests that advertisers might benefit from poaching static images of individuals—from, say, social media sites such as Facebook—to personalize their pitches.

The most alluring spokesbeings of all, however, might be fully maneuverable doppelgänger avatars of the type featured in high-immersion virtual worlds such as Second Life. When Stanford students entered an immersive virtual setting featuring their doppelgänger in a soft-drink T-shirt, they highly endorsed the product on the shirt—provided they could control and manipulate their digital replica. (Students responded negatively, however, to doppelgängers they could only watch but not control; in this case, they opted for the competing beverage displayed on a stranger avatar's T-shirt.)

Such studies indicate the degree to which our opinions may be vulnerable to influence by anyone who decides to take and manipulate our digital image and put it before us. "Our identities are on the verge of becoming that mash-up of our physically real and virtual self or selves," says sociologist Sherry Turkle

Avatar programs could provide social cues and stimulation to help people with social phobias gain courage to interact.

Personalizing advertisements with pictures of individuals could exert particular power over consumers. People preferred a brand of soft drink that appeared with their own picture to one accompanied by a photograph of a stranger or shown with only a text endorsement.



COURTESY OF CODY KARUTZ



of the Massachusetts Institute of Technology.

Equally unsettling is the potential of avatars to imbue us with false memories. In 2009 Bailenson and Stanford communications researcher Kathryn Segovia told each of 27 preschool and 28 elementary school children a fictional story about the child's having once swum with two orca whales named Fudgy and Buddy. Then some of the children were told to spend a minute envisioning themselves swimming with the whales. Other kids watched their own doppelgänger avatar in the ocean with the mammals, and a third group saw another child in a virtual-reality enactment of the swim. A fourth group simply sat for a minute and waited. Five days later Segovia and Bailenson asked the children to describe their experience swimming with the whales and to judge whether the encounter had been real.

Nearly all the preschoolers thought they had actually swum with whales; such young children generally do not distinguish among real, virtual and imagined sources of information. More surprisingly, four of the seven elementary school children who had seen their avatar with the whales believed at least parts of the adventure to have been their own. Active visualization of the event was also convincing to the same proportion of these older children. (In contrast, watching a virtual representation of another child fooled only one of the kids.) Some of the children even embellished the avatar experience, with tales of playing hide-and-seek in coral reefs with the whales, for example. These findings indicate that in manipulating memories, showing children fictitious scenes involving doppelgänger avatars can be just as effective as coaxing them to imagine detailed scenarios that never happened.

Avatar experiences are likely to have a similar effect on the memories of adults, according to psychologist Elizabeth Loftus of the University of California, Irvine. People distinguish real memories from fake ones, she says, by recollecting details of sights and sounds. Thus, digital media embedded with these sensations can completely confound the memory. Loftus worries that viewing avatars might exert even more power over people's memories than fantasizing does. Fantasies require effort to create and thus may be more under a person's conscious control, she explains. In contrast, watching avatars is passive. "These kinds of images can invade you like a Trojan horse because you can't even detect that it's happening," she says. But even the potential of avatars to implant memories could be put to good use—if, say, the experience could link an aversive memory with an undesirable behavior, such as gorging on desserts, Loftus suggests.



Avatar-based programs seem ready to advance from experimental to commercial. Very soon you might be able to buy doppelgänger apps or video games to help you lose weight, understand the consequences of financial irresponsibility, develop your social skills, ease your anxieties or even promote cultural sensitivity. So far at least one exercise program is in early-stage commercial development. Further into the future, experts imagine, your psychotherapist may be someone on a computer speaking through an animated picture of your own face—after all, who can you trust more than yourself?

Other implications of such avatars may be far-reaching and unpredictable. "Seeing yourself do something that you've never done is something that, as humans, we've never experienced before," Bailenson says. As each of us becomes acquainted with our cyber-replicas, we may increasingly feel as if more than one of us exist. **M**

**Simulations involving look-alike avatars can implant false memories. In one study, schoolchildren who had simply viewed their avatar swimming with two orca whales later believed they had done so in real life.**

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# Does Alcoholics Anonymous Work?

For some heavy drinkers, the answer is a tentative yes

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

ALCOHOLICS ANONYMOUS, celebrating its 76th anniversary this year, counts two million members who participate in some 115,000 groups worldwide, about half of them in the U.S. How well does it work? Anthropologist William Madsen, then at the University of California, Santa Barbara, claimed in a 1974 book that it has a “nearly miraculous” success rate, whereas others are far more skeptical. After reviewing the literature, we found that AA may help some people overcome alcoholism, especially if they also get some professional assistance, but the evidence is far from overwhelming, in part because of the nature of the program.

Alcoholics Anonymous got its start at a meeting in 1935 in Akron, Ohio, between a businessman named Bill Wilson and a physician, Bob Smith. “Bill W” and “Dr. Bob,” as they are now known, were alcoholics. Wilson had attained sobriety largely through his affiliation with a Christian movement. Smith stopped drinking after he met Wilson, whose success inspired him. Determined to help other problem drinkers, the men soon published what has become known as “The Big Book,” which spelled out their philosophy, principles and methods, including the now famous 12-step method [see box on opposite page]. *Alcoholics Anonymous* was the book’s official title and also became the name of the organization that grew from it.



Bill Wilson and Bob Smith, the founders of Alcoholics Anonymous, wrote “The Big Book” at the desk above.

In AA, members meet in groups to help one another achieve and maintain abstinence from alcohol. The meetings, which are free and open to anyone serious about stopping drinking, may include reading from the Big Book, sharing stories, celebrating members’ sobriety, as well as discussing the 12 steps and themes related to problem drinking. Participants are encouraged to “work” the 12-step program, fully integrating each step into their lives before proceeding to

the next. AA targets more than problem drinking; members are supposed to correct *all* defects of character and adopt a new way of life. They are to accomplish these difficult goals without professional help. No therapists, psychologists or physicians can attend AA meetings unless they, too, have drinking problems.

## A for Abstinence?

Most studies evaluating the efficacy of AA are not definitive; for the most part, they associate the duration of participation with success in quitting drinking but do not show that the program caused that outcome. Some of the problems stem from the nature of AA—for example, the fact that what occurs during AA meetings can vary considerably. Further, about 40 percent of AA members drop out during the first year (although some may return), raising the possibility that the people who remain may be the ones who are most motivated to improve.

Nevertheless, the results of one well-designed investigation called Project Match, published in 1997, suggest that AA can facilitate the transition to sobriety for many alcoholics. In this study, a group of prominent alcoholism researchers randomly assigned more than 900 problem drinkers to receive one of three treatments over 12 weeks. One was an AA-based treatment called 12-step facilitation therapy that includes contact with a profes-

( AA targets more than drinking; members are to correct all character defects and **adopt a new way of life.** )

COURTESY OF HAL ARKOWITZ (Arkowitz); COURTESY OF SCOTT O. LILIENFELD (Lilienfeld); KAREN VIBERT-KENNEDY AP Photo (Wilson's home desk)

sional who helps patients work the first few of the 12 steps and encourages them to attend AA meetings. The other treatments were cognitive-behavioral therapy, which teaches skills for coping better with situations that commonly trigger relapse, and motivational enhancement therapy, which is designed to boost motivation to cease problem drinking.

The AA-based approach seemed to work and compared favorably with the other therapies. In all three groups, participants were abstinent on roughly 20 percent of days, on average, before treatment began, and the fraction of alcohol-free days rose to about 80 percent a year after treatment ended. What is more, 19 percent of these subjects were teetotalers during the entire 12-month follow-up. Because the study lacked a group of people who received no treatment, however, it does not reveal whether any of the methods are superior to leaving people to try to stop drinking on their own.

Other research suggests that AA is quite a bit better than receiving no help. In 2006 psychologist Rudolf H. Moos of the Department of Veterans Affairs and Stanford University and Bernice S. Moos published results from a 16-year study of problem drinkers who had tried to quit on their own or who had sought help from AA, professional therapists or, in some cases, both. Of those who attended at least 27 weeks of AA meetings during the first year, 67 percent were abstinent at the 16-year follow-up, compared with 34 percent of those who did not participate in AA. Of the subjects who got therapy for the same time period, 56 percent were abstinent versus 39 percent of those who did not see a therapist—an indication that seeing a professional is also beneficial.

These findings might not apply to all problem drinkers or AA programs, however. Because this study was “naturalistic,” that is, an investigation of people who chose their path on their own (rather than as part of the study), the researchers could not control the precise makeup of the meetings or treatments. Furthermore, the abstinence rates reported might apply only to those with

## 12 Steps to Sobriety?

In Alcoholics Anonymous, members try to abstain from alcohol by working through the 12 steps listed below. Secular alternatives include Self-Management and Recovery Training ([www.smartrecovery.org/](http://www.smartrecovery.org/)) and Secular Organizations for Sobriety ([www.cfiwest.org/sos/index.htm](http://www.cfiwest.org/sos/index.htm)).

1. Admit our powerlessness over alcohol.
2. Believe that a Power greater than ourselves can restore us to sanity.
3. Decide to turn our will and lives over to God as we understand Him.
4. Conduct a moral inventory of ourselves.
5. Admit our wrongs to God, ourselves, and another person.
6. Are ready to have God remove all defects of character.
7. Ask Him to remove our shortcomings.
8. List all persons we have harmed, and be willing to make amends to them.
9. Make such amends wherever possible.
10. Continue to take personal inventory and admit any wrongs we find.
11. Pray and meditate to attain knowledge of God's will for us and for the power to carry it out.
12. Awaken spiritually to practice the 12 steps in all of our affairs, and carry this message to other alcoholics.

SOURCE: Adapted from the AA Web site: [http://aa.org/en\\_pdfs/smf-121\\_en.pdf](http://aa.org/en_pdfs/smf-121_en.pdf)

less severe alcohol problems, because the scientists chose people who sought help for the first time, excluding others who had done so in the past. Various studies have found that a combination of professional treatment and AA yields better outcomes than either approach alone.

### Constructive Combination

Taken as a whole, the data suggest that AA may be helpful, especially in conjunction with professional treatment, for many people who are addicted to alcohol. We do not know, however, whether AA might occasionally be harmful. When a group is highly confrontational, for example, alcoholics may become resistant to change [see “The Advice Trap,” by Hal Arkowitz

and Scott O. Lilienfeld; SCIENTIFIC AMERICAN MIND, September/October 2010]. Nevertheless, in light of the evidence supporting the program, the wide availability of meetings and the lack of expense, AA is worth considering for many problem drinkers. **M**

HAL ARKOWITZ and SCOTT O. LILIENFELD serve on the board of advisers for *Scientific American Mind*. Arkowitz is a psychology professor at the University of Arizona, and Lilienfeld is a psychology professor at Emory University. The authors thank William R. Miller of the University of New Mexico and Rudolf Moos of Stanford University for their help with this column.

Send suggestions for column topics to [editors@SciAmMind.com](mailto:editors@SciAmMind.com)

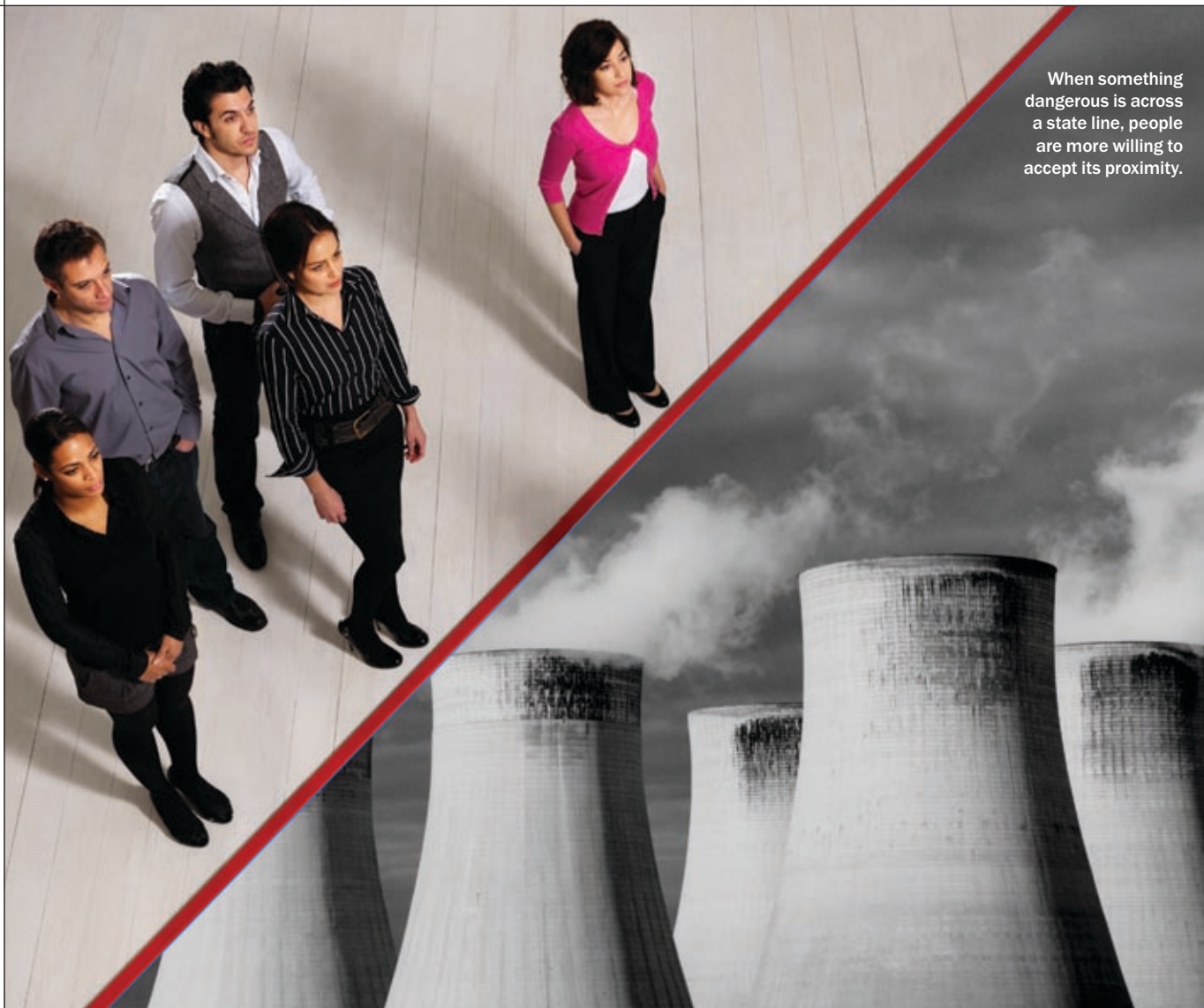
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# Border Bias

Our mental maps of risk and safety rely too heavily on imaginary boundaries

BY WRAY HERBERT



When something dangerous is across a state line, people are more willing to accept its proximity.

I ONCE LIVED within a short walking distance of a state line, and I had a friend who lived right on the avenue that was the dividing line. That meant she could be cutting her lawn while watching her neighbor cut his lawn in a different state. Living on a border loses its novelty after a while, but visitors always find it intriguing. They seem to expect the Berlin Wall or some other concrete demarcation of an abstract political division.

This curiosity arises because of cognitive mapmaking, which is different from regular mapmaking. Cartographers measure and plot distances over land and water, but when we make a mental map, we rely on categories to help us keep things straight. States are one of these categories. For example, we think of Spokane and Olympia as close because they are both in the state of Washington, even though Olympia is actually

much closer to Portland, Ore. The map-maker in our neurons favors the category over actual proximity.

What are the implications of this bias? Two psychological scientists at the University of Utah (in Salt Lake City, in north-central Utah) wondered if our mental maps might skew the way we think about the risk of a disaster. In other words, if we think of state borders as physical barriers, do we also irrationally

MATT MENDELSON (Herbert); JUPITERIMAGES (people); GETTY IMAGES (smokestacks)

A light, sketchy border minimized the distinction between Utah and Nevada—and thus increased subjects' perception of risk.

imagine that these borders protect us in some way? The scientists, husband-and-wife team Arul Mishra and Himanshu Mishra, decided to test this idea in the lab.

They recruited a large group of volunteers from 32 states and asked them to imagine building a mountain home in the Pacific Northwest—either in North Mountain Resort, Wash., or in West Mountain Resort, Ore. While they were contemplating the choice, the volunteers received a news alert about an earthquake, but the details differed. Some heard that the earthquake had hit Wells, Wash., 200 miles from both vacation home sites. Others heard that the earthquake had struck Wells, Ore., also 200 miles from both home locations. They were warned of continuing seismic activity, and they were also given maps showing the locations of both home sites and the earthquake, to help them make their choice of vacation homes.

### Not in My State's Backyard

Their choices revealed a clear border bias. Even though they knew that both homes were exactly 200 miles from the disaster, home shoppers perceived in-state home locations to be significantly riskier than out-of-state locations. In other words, they disregarded actual distance and made their risk assessment based on political borders that have nothing to do with seismology.

This thinking is irrational, of course. So the Mishras decided to look at the question a different way—this time in a case involving environmental risk. They recruited volunteers from Salt Lake City and told them about a radioactive waste facility being built 165 miles away. They were warned that radioactive waste, if not



Although Oklahoma City is about 100 miles nearer to Amarillo than Dallas is, residents of Amarillo probably feel psychologically closer to the other Texas city and would be more worried about trouble there.

contained properly, could contaminate soil, water and air for hundreds of miles. Some volunteers were then told that the waste facility would be in Sevier Lake, Utah, whereas others heard that it was being constructed in Spring Creek, Nev.

So far this sounds a lot like the earthquake experiment, but the scientists added a twist by giving the volunteers different maps. Some saw a map in which the Utah-Nevada border was drawn as a thick, dark line, whereas others got a map showing the border as a light, dotted line. The idea was that the dark line would reinforce the biased notion that borders are impermeable—and that states are therefore meaningful categories to rely on for decision making.

And that is just what happened. As reported in October in the online version of the journal *Psychological Science*, when the radioactive waste was being stored in neighboring Nevada, residents of Salt Lake City perceived much greater

risk of contamination if the border was a light, dotted line. In their minds, that light, sketchy border minimized the distinction between Utah and Nevada—and thus increased their perception of risk. The thick, dark border offered psychological protection from radioactivity.

Such irrational risk assessment has practical implications, the scientists note. Most obviously, disaster warnings would be much more effective if they emphasized actual distance rather than abstract political demarcations. Tornadoes and

hurricanes and other perilous weather formations do not honor state lines. But in addition, citizens would be able to make better decisions about insurance coverage if they were given more meaningful information about the proximity of risk. Finally, citizen activism could be more rationally organized. Oftentimes residents will protest toxic waste dumps and other health threats only within their state borders, feeling immune to identical risks that are in neighboring states but even closer by. Understanding border bias could lead to more sensible and effective citizenship. **M**

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

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

### (Further Reading)

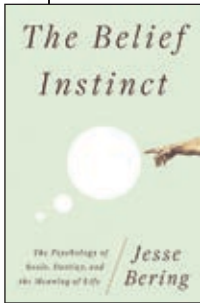
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books

FAITH

The Belief Instinct

by Jesse Bering. W.W. Norton, 2010 (\$26.95)



Why do so many people believe in God? Evolutionary psychologist and Scientific American blogger Jesse Bering has a novel answer to this tired question. In *The Belief Instinct*, he explains that although the evolution of language was beneficial—allowing us to communicate easily and disseminate important

information—it also brought with it a deeply troubling problem for early humans. Language allowed onlookers to report on someone else’s behavior long after the event had occurred. This meant that if you were caught doing something objectionable, such as stealing, you had “foolishly gambled away” your reputation and consequently your reproductive prospects. Thus, believing in a supernatural

being who monitored and judged anyone at all times encouraged people to avoid acting on their immoral impulses, helping them survive, Bering says.

Gossiping, however, was not the only trait that prompted humans to believe in God. Bering argues that our ability to think about what others think, known as “theory of mind,” also played an important role. He writes that our “overzealous” theory of mind motivates us to get “into God’s head” and look for hidden meaning or messages embedded in any event, such as if your alarm clock fails to go off or a hurricane floods your basement. In fact, without this cognitive bias, “much of religion as we know it would never have gotten off the ground,” Bering asserts.

While building his case, Bering tells us about intriguing research, including studies that explored whether chimpanzees have a theory of mind (a definite answer remains elusive) and whether older children are more likely to be superstitious (surprisingly, Bering’s work shows that children six to seven years old see hidden messages in events for which those three to four years

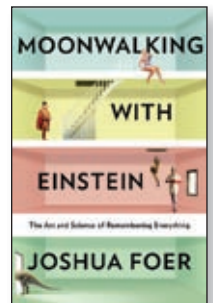
old find only rational explanations).

The book’s sharp humor is refreshing and entertaining, but one of its greatest strengths is its clarity. Bering does not use jargon or tiptoe around what he thinks. Of course, we may never know whether his theory is correct, but it certainly injects a breath of fresh air into what seems to have become a stale discussion. —Nicole Branan

MEMORY TRIP

Moonwalking with Einstein: The Art and Science of Remembering Everything

by Joshua Foer. Penguin Press, 2011 (\$26.95)



When Joshua Foer showed up at the U.S. Memory Championships in 2005, he thought he was going to write a quirky story about some brainy oddballs with impressive memories. He didn’t suspect that this venture would introduce him to the complexities of mnemonic devices, teach him some ancient history and lead him to uncover his own mental prowess. He returned the following year as a top contender.

While researching *Moonwalking with Einstein: The Art and Science of Remembering Everything*, Foer learned that becoming a grand master of memory requires accomplishing several seemingly impossible objectives. You have to remember the order of 10 shuffled decks of playing cards in less than an hour, 1,000 digits in the same amount of time, and one shuffled deck in less than two minutes. The winner takes home a trophy and a ticket to the World Memory Championships in London.

Foer knew he had an average, even slipshod, memory—one that could retain about seven items in the short term. Somehow, though, he learned how to jam his brain with more random information than he ever thought possible.

He was able to beef up his memory by learning mnemonic techniques. These methods, first employed by a Greek poet in the fifth century B.C. and later by artists and intellectuals from Cicero to Mark Twain, are based on a concept called elaborative encoding, which posits that the more meaningful something is, the easier it is to remember. Our brains are ill equipped to remember symbols, such as



Roundup: Bonds That Bind

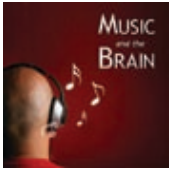
Who we know determines who we are. Three new books reveal how much heroes and even distant acquaintances influence us.

Surprisingly, a \$10,000 raise may not make you as content as simply knowing a friend of a friend of a friend is happy, says sociologist Nicholas A. Christakis and political scientist James H. Fowler in their landmark book **Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives** (Little, Brown, 2009). The authors draw on the famous Framingham Heart Study to show that, although we may not realize it, those on the fringes of our social networks dramatically affect our moods, political leanings and even waist size.

In **Heroes: What They Do and Why We Need Them** (Oxford University Press, 2011), psychologists Scott T. Allison and George R. Goethals argue that a single larger-than-life individual, such as Lucretia Mott, America’s first feminist, or Martin Luther King, Jr., has the power to influence a diverse group. We identify with these heroic figures because they make us feel good about ourselves.

Peer pressure is not just about gateway drugs, awkward school dances and eating disorders—it can also motivate positive social change. In **Join the Club: How Peer Pressure Can Transform the World** (W. W. Norton, 2011), MacArthur fellow and award-winning journalist Tina Rosenberg demonstrates how peer pressure has helped minority students raise their grades and reduced teen smoking in the U.S. —Ferris Jabr

CORBIS



► **MELODIC POWER**

**Music and the Brain**

U.S. Library of Congress  
(free online at [www.loc.gov/podcasts/musicandthebrain/index.html](http://www.loc.gov/podcasts/musicandthebrain/index.html))

The sparkling sounds of a Mozart piano concerto, the tragic wails of a Wagner aria—there is no question that music has a profound influence on the mind. Not only does it evoke powerful emotions, but research suggests that listening to and making music can also shape brain development, help treat neurological conditions such as clinical depression and even reduce the propensity to commit crimes. These topics receive in-depth coverage in *Music and the Brain*, a podcast series created by the Library of Congress.

In each 20-minute show, veteran radio host Steve Mencher invites his guests, who include scientists, composers, performers and physicians, to discuss their research, exploring the effects music has on the brain. The shows typically begin with Mencher asking somewhat off-topic questions.

The second half of each episode, which focuses on recent

scientific discoveries, is the most interesting part. Gottfried Schlaug, director of the music, neuroimaging and stroke recovery laboratories at Beth Israel Deaconess Medical Center in New York City, addresses the ways in which the brains of musicians and nonmusicians differ. He suggests that making music during youth enhances the development of the interior frontal gyrus, a region that connects the motor and auditory systems. Vera Brandes, director of the research program in music medicine at the Paracelsus Private Medical University of Salzburg in Austria, talks about the healing potential of both making and listening to music. “The healthiest people on this planet are singers,” she explains, in part because their focus on breathing helps keep the body properly infused with oxygen.

McGill University music psychologist Daniel Levitin delves deeply into the effects of music on humanity, arguing that songs have largely shaped human evolution. When people sing together, he describes, their bodies release the hormone oxytocin, which promotes bonding: “Singing may have been an important way in which ancient humans formed social bonds in order to create societies.” Given all the powerful ways in which music affects the mind, it could very well be a cornerstone of our existence. —Melinda Wenner Moyer

numbers and playing cards. But by translating dull sets of digits into vivid (even lewd) images, it is possible to remember large amounts of information. For example, when Foer wanted to remember “e-mail Sophia,” he conjured up an image of Sophia Loren sitting on the lap of a “she-male” who was typing on a computer in the den in his childhood home.

This memorization process engages areas of the brain involved in spatial navigation and visual recognition, including the right posterior hippocampus. In ancient Rome, these mnemonic techniques were considered so routine that they did not merit elaboration, but by the 20th century they had nearly vanished, until the World Memory Championships began in 1991.

Foer’s history of memory is rich with information about the nature of memory and how it makes us who we are. Now that he has committed the story to paper, perhaps there is far less chance we will forget how to remember. —Frank Bures

► **MATERIAL CONNECTION**

**Stuff: Compulsive Hoarding and the Meaning of Things**

by Randy O. Frost and Gail Steketee.  
Houghton Mifflin Harcourt, 2010 (\$27)

Most of us understand what it is like to have an emotional connection with a cherished possession. How about that ratty rabbit you’ve owned since you were

three? The sentimental value attached to this stuffed pet makes even the thought of parting with it painful. But imagine you felt as strongly about every single item in your room, including the magazines from two decades ago and the clothes that no longer fit. Hoarders form intense attachments to even their most trivial possessions—everything seems worth keeping.

In the riveting new read *Stuff: Compulsive Hoarding and the Meaning of Things*, Randy O. Frost, a Smith College psychologist, and Gail Steketee, dean of the Boston University School of Social Work, reveal the world of hoarding disorders. The homes of hardcore hoarders, who represent up to 5 percent of the population, are more trash dumps than living spaces. It is only possible to navigate their interiors using “goat paths,” narrow trails that wind through the mounds of books, old food, clothes, trinkets and containers.

Frost and Steketee explore why hoarders find their compulsive behaviors so pleasurable (hoarding may activate the same reward centers in the brain as addictive drugs such as cocaine do), where the compulsion to hoard originates (at least one study suggests the impulses are imprinted in our genes), and how hoarders live.

To illustrate this pathology, the authors describe several case studies.



Meet Pamela, a filmmaker who kept more than 200 cats, until her neighbors and the American Society for the Prevention of Cruelty to Animals intervened. And Daniel, a 50-year-old man who scavenged so many objects from the streets of Manhattan cockroaches stained the walls of his apartment brown with their dung.

The authors argue that hoarders see potential and value in objects most of us do not. In fact, hoarders have exceptional powers of observation and attention to detail that far surpass the average Joe. They notice every hue on the cover of a magazine, every crack in a vase. “When I am trying to decide what to keep, this outdated coupon seems as important as my grandmother’s picture,” says Irene, a librarian whose disorder led to divorce.

*Stuff* also demonstrates that hoarding disorders can be treated. Over a period of 18 months the authors worked with Irene to change the thoughts and behaviors responsible for the disarray of her home. They helped Irene create an efficient filing system for all her belongings and taught her to remove or hide objects before she could develop superfluous attachments. Eventually Irene and her family began to live in a home that was virtually clutter-free—a kind of freedom they had not known for years.

—Ferris Jabr

# asktheBrains

## When do human beings start to dream?

—William Keith, Houston, Tex.



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

**PINPOINTING WHEN** humans begin to dream remains an elusive challenge, although scientists have some ideas. There are researchers who argue that dreams originate as early as in the mother's womb, whereas others posit that they first occur when a child's brain becomes more developed, around five to seven years old.

Self-reports of dreams provide the only reliable evidence that a person can dream. Unfortunately, it is impossible to ask a newborn infant or a fetus whether it had a dream last night. Instead scientists can gather clues about when we begin to dream by monitoring certain physiological markers while a person is asleep, such as brain waves, muscle tension and eye movements.

One stage of sleep, in particular, often indicates when a person is dreaming. This stage, called rapid eye movement, or REM sleep, typically occupies about 20 percent of an adult's night sleep. Newborn babies may spend more than 80 percent of their total sleep time in REM.

Fetuses also experience REM sleep. Studies using ultrasound have shown that fetuses exhibit REM sleep as early as the 23rd week of gestation.

Although scientists can detect REM activity in fetuses, they cannot know for certain whether this physiological activity, specifically eye movements, indicates that the fetus is dreaming. This inability to determine what is happening is because humans do not necessarily always dream during REM sleep, and humans can dream outside of this sleep stage.

But even if we could assume, for a

moment, that fetuses dream, what would they imagine in their sleep? And how much would their dreams differ from those children and adults have? These questions are certainly worth sleeping on.

## Do genes make people evil?

—Robert Schreib, Jr.,  
Toms River, N.J.



**Daniel Lametti**, a neuroscientist at McGill University, responds:

**THE MONTREAL** apartment where I live is rife with evildoers—well, to be precise, there is at least one. A couple of weeks ago my newspaper, routinely delivered at 5 A.M. to my building's lobby, disappeared before I could scurry out of bed to collect it. To thwart the criminal, I asked my deliveryman to hurl the paper onto my third-floor balcony (thankfully, he has a good arm).

Admittedly, newspaper theft ranks low on the scale of evil acts. Still, I wouldn't steal a newspaper. I would like to think that under most circumstances I wouldn't steal at all. But many people do, and many also commit crimes that are much more sinister.

Scientists would like to know the root causes of evil behavior: Is it a product of our genes or environment? The answer appears to involve a combination of the two.

Since the 1960s psychologists have found that children who were abused and neglected are more likely to commit crimes later in life. Even so, researchers noted that most youngsters who are mistreated do not grow up to be criminals. Now our genes come into the picture.

A 2002 study found that a particular variation of a gene predicted antisocial behavior in men who were mistreated as children. The gene controls whether we

Even if we could assume that fetuses dream, what would they imagine in their sleep? And how much would their dreams differ from those children and adults have?

produce an enzyme called monoamine oxidase A (MAOA), which at low levels has been linked to aggression in mice. The researchers found that boys who were neglected and who possessed a variation of the gene that produced low levels of MAOA were more likely to develop antisocial personality disorder, commit crimes and grow up to have a violent disposition. But those living in a similar environment who produced more of the enzyme rarely developed these problems.

Psychopaths are arguably the vilest of the evildoers. A study published in August 2010 looked at psychopathic tendencies in teenagers with low socioeconomic resources. The researchers found that adolescents who had a variation of another gene, which contributes to how quickly serotonin is recycled in the brain and which has been linked to hostile behavior in children, were more likely to exhibit signs of psychopathy.

These two recent findings provide strong evidence that evil behavior—mass murder, armed robbery, and perhaps even newspaper theft—might be caused by the right set of genes interacting with the wrong environment. **M**

Have a question? Send it to [editors@SciAmMind.com](mailto:editors@SciAmMind.com)

COURTESY OF PAUL LI; COURTESY OF DANIEL LAMETTI

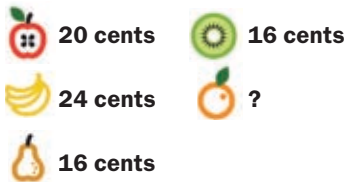


# Head Games

Match wits with the Mensa puzzlers

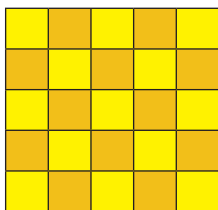
## 1 TUTTI FRUTTI

An eccentric grocer has priced all the fruit in his store according to his own unusual system. According to his rules, how much should the orange cost?



## 2 THOUGHTFUL SQUARE

Place the letters used in the word THINK in the square below so that every row across and down and the two major diagonals have each of the five letters in it. To make it a little more difficult, you may use only anagrams of the word and never the word itself; that is, no line may spell THINK. There are several solutions.



## 3 DOUBLE ANAGRAM

The 10 letters shown below can be arranged and rearranged to form two common English words. Find both.

**A T N M I I G C D E**

## 4 MYSTERY NUMBER

Find the five-digit number in which the second digit is half the first digit and one third the third digit; in which the fourth digit is the same as the second; in which the sum of the first two digits equals the third digit; and in which the last two digits make a number that is the square of the first digit.

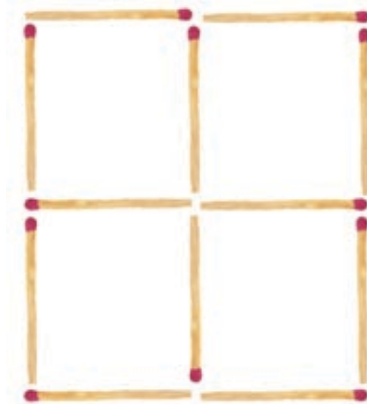
## 5 ZOOLOGIC

The zoo houses birds, animals and exotic insects. There are six times as many two-legged birds as there are six-legged insects and three times as many birds as there are four-legged animals. There are 104 legs total.

How many of each type of animal are in the zoo?

## 6 MEET YOUR MATCH

Move exactly four of the 12 matches below and make only two squares.



## 7 WORD MAZE

Find the right starting letter and trace a path in any direction, using each letter only once, to reveal a proverb. There is one null letter.

**D O O G R**  
**D E E O D**  
**U S N D E**  
**N E O G H**  
**P U N I S**

## 8 FEELING TAXED

The price of a new coat in Never-Never Land is \$100. That includes, unfortunately, a 6 percent tax for the upkeep of Captain Hook's ship, a 10 percent tax for renewing fairy dust supplies, and a 9 percent transportation tax on all flying activities or clothes worn while flying.

What would the coat have cost if you did not have to subsidize all this Never-Never activity?

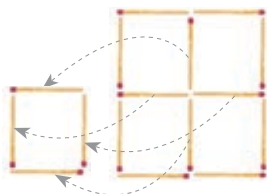
## 9 ODD MAN OUT

Unscramble the words below to determine which one does not belong with the rest.

**YHNAE**    **TGRIE**  
**FFEGRIA**    **GALEE**

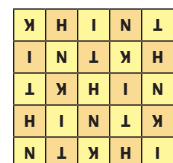
## Answers

7. No good deed goes unpunished.  
 8. \$80.  
 9. EAGLE. (The others are HYENA, TIGER and GIRAFFE.)




4. 63,936.  
 5. Four insects, eight animals and 24 birds.

3. DECIMATING, MEDICATING.



1. 24 cents, at four cents per letter.  
 2. One possible answer:

**I Think, therefore...  
I SCAN?** by Dwayne Godwin  
and Jorge Cham



DO YOU EVER WISH YOU  
COULD READ MINDS?

PHRENOLOGISTS BELIEVED THEY  
COULD DO IT BY READING THE  
BUMPS ON YOUR HEAD.

i can tell you  
are ... clumsy.



THIS IDEA HAS BEEN DEBUNKED ...


... BUT IN THE 1920s  
SURGEONS DID FIND THAT  
CERTAIN AREAS OF THE  
BRAIN CORRESPOND TO  
SPECIFIC BRAIN FUNCTIONS.

whoops, that must  
control the leg.



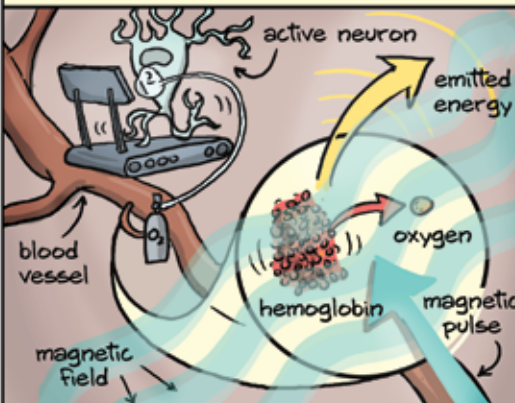
IT IS THIS IDEA THAT  
MODERN FMRI MACHINES  
TAKE ADVANTAGE OF TO  
SCAN YOUR THOUGHTS.

hope you're not  
claustrophobic, too!



FMRI WORKS BY MEASURING  
THE OXYGEN CONSUMED BY  
ACTIVE NEURONS.

WHEN NEURONS TAKE IN OXYGEN FROM  
THE BLOODSTREAM, THE MAGNETIC  
PROPERTY OF THE HEMOGLOBIN CHANGES.



POWERFUL MAGNETS IN THE MACHINE  
ALIGN THE HEMOGLOBIN MOLECULES, THEN  
CAUSE THEM TO SPIN AND EMIT ENERGY.


BY MEASURING THIS  
ENERGY, THE MACHINE  
CAN TELL WHICH AREAS  
ARE MORE ACTIVE WHEN  
WE THINK, FEEL OR PLAN  
SPECIFIC ACTIONS.



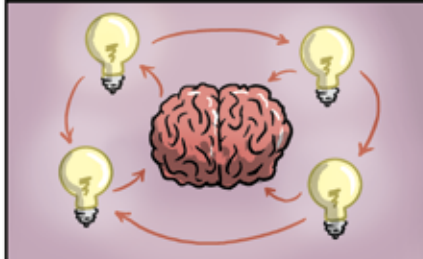
BUT IT'S NOT  
FOOLPROOF ...

IN 2009 SCIENTISTS PUT A  
DEAD SALMON IN AN FMRI  
MACHINE AND GOT WHAT  
LOOKED LIKE A LIVE SIGNAL!

sure it's not a  
red herring?



FMRI CAN SHOW US  
ACTIVITY, BUT LIKE OTHER  
METHODS IT HAS LIMITS ...



FOR EXAMPLE, IT CAN'T TELL US  
HOW THINGS ARE CONNECTED TO  
ONE ANOTHER IN THE BRAIN.

SO WHILE NEITHER BUMPS  
NOR MAGNETIC SIGNALS CAN  
GIVE YOU THE FULL PICTURE,  
YOU CAN ALWAYS TRY MORE  
TRADITIONAL METHODS:



a penny for  
your thoughts?

● Dwayne Godwin is a neuroscientist at the Wake Forest University School of Medicine.  
Jorge Cham draws the comic strip Piled Higher and Deeper at [www.phdcomics.com](http://www.phdcomics.com).

One in two men and one in three women  
will be diagnosed with cancer in their lifetimes.



↑  
Molly Lewis  
Survivor

↑  
Linda Person  
Oncology nurse

↑  
Judith Opdahl  
Patient advocate,  
survivor

↑  
Dr. Peter Jones  
SU2C Dream Team  
cancer researcher

↑  
Jimmy Smits  
Actor,  
Cancer advocate

# When we all stand up, cancer will stand down.

**Cancer, be afraid.** We are survivors, families, doctors, nurses, researchers, and advocates working together to end this disease. The best and the brightest in the cancer community are coming together to Stand Up To Cancer.

**Are you with us? Stand up with us.** Together, we are changing the way we fight cancer, and we won't stop until we win.

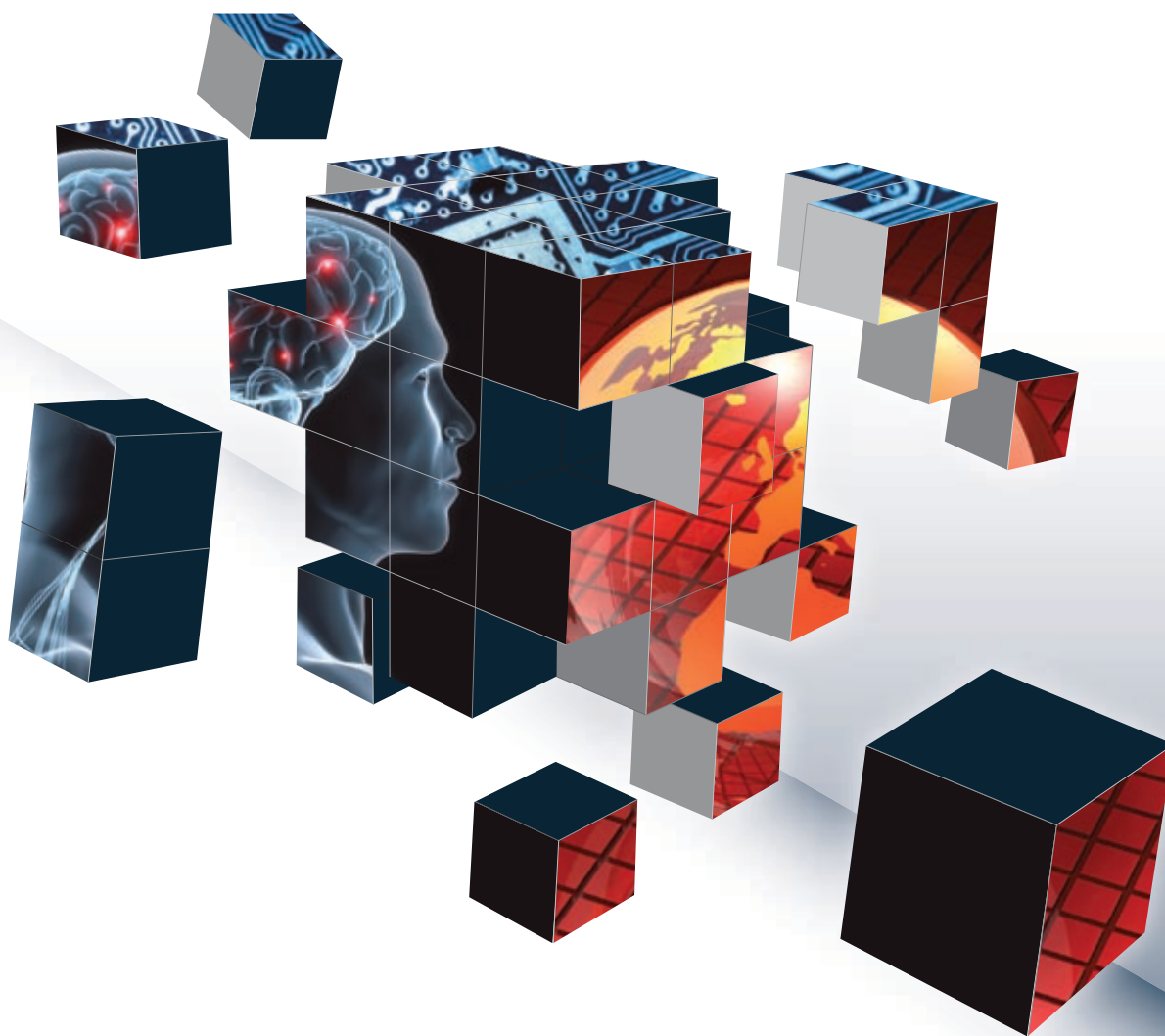
Photo by Randall Slavin



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