LOOKING FOR LOVE IN ALL THE RIGHT PLACES page 18

SCIENTIFIC AMERICAN
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March/April 2012 www.ScientificAmerican.com/Mind

SPECIAL REPORT
Your *Real* Extrasensory Perceptions
page 44

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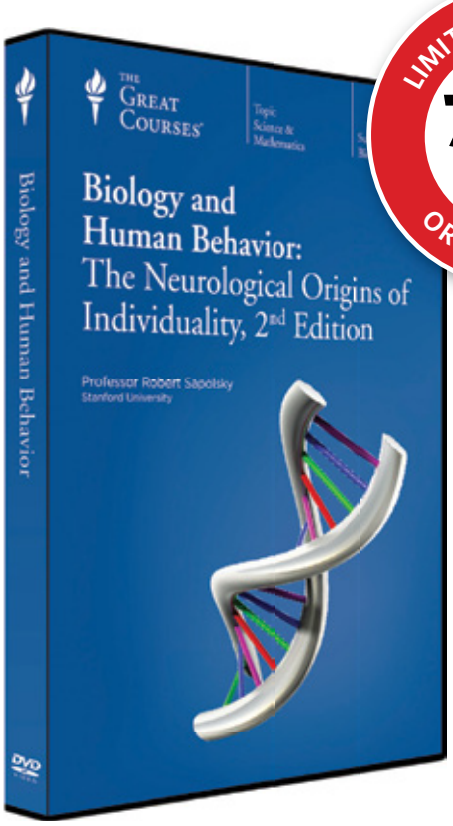

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SCIENTIFIC AMERICAN MIND
Volume 23, Number 1, March/April 2012

FEATURES

SPECIAL REPORT
SENSATIONAL SENSES

COVER STORY

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DEPARTMENTS

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Mental Overload

Not long ago I signed up for an improvisational theater class. I thought I might gain stage presence and confidence; little did I know I would encounter a genuine cognitive challenge. Within seconds of stepping into a new scene, you must assign yourself a character, convey a location and jump into an activity. You must also react convincingly to your scene partner's responses. Spinning a believable narrative out of two actors' choices is like keeping a beach ball aloft no matter what awkward trajectory it may have spun off on.

Learning improv has brought home two main ideas of this issue. Pursuing all the goals needed to improvise a scene can feel just as demanding as, say, answering an important e-mail while taking a phone call. Clearly, I am not a "supertasker"—one of those rare people who *can* flawlessly execute multiple challenges at once. Psychologists David L. Strayer and Jason M. Watson study these lucky individuals, and they share their discoveries in "Supertaskers and the Multitasking Brain," on page 22.

To build a convincing scene, improvisers tune their eyes and ears to the thoughts and emotions of the other performers. The special section "Sensational Senses," starting on page 44, explores the bedrock of that ability. The brain possesses sensory skills far more exotic than what we usually think of as sight, smell, hearing and taste, as journalist Ariel Bleicher writes in "Edges of Perception," on page 46. Some of the clues gleaned by our senses enable us to form social bonds, as psychologists Janina Seubert and Christina Regenbogen explain in "I Know How You Feel," on page 54. Years later those perceptions can act like landmines in the brain, unearthing a trove of memories. Delve into Maria Konnikova's "Smells Like Old Times," on page 58.

These themes are deeply related. The act of multitasking alters how we perceive the world as we travel through it. Multitasking divides our attention, which forces the brain to discard critical sensory signals and influences how we think. To engage fully in an experience, however, all you need to do is focus.

Sandra Upson
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DREAM STATES

Deirdre Barrett's article, "Answers in Your Dreams," brought back memories. In 1960 I was the first woman pioneer in the EEG study of sleep and dreams.

Barrett mentions William Dement's 1972 study. I took part in an earlier effort by Dement while working on my dissertation at Mount Sinai Hospital. Dement called with a problem-solving experiment he wanted to try: "Tell your subject, 'The letters 'O T T F F' are the first letters in a well-known series. Once you add the next two letters correctly, you can add an infinite number of letters.'" (The next two are "S S" for "six" and "seven.") I gave the problem to a subject in my sleep lab before she went to bed, and in the morning she said she had dreamt a lot.

"I was in Bloomingdale's," she said. "I was looking at a list of things I needed to buy, and at the end of the list was written 'Silk Stockings'—the point is, on my list, it wasn't written out, just the letters 'S S.' Isn't that silly?"

I was dumbfounded. After she left I called Dement from a pay phone in the hospital. "I think it means she was trying—she came awfully close," he exclaimed. "What an incredible coincidence!" Nice, huh?

Judith S. Antrobus
New York City

IN DEFENSE OF PRESCHOOL

As a longtime reader of your magazine, I was quite surprised to open this month's issue and find the preschool I send my children to savaged in "The Death of Preschool," by Paul Tullis.

Although Tullis quoted many fine scientific studies about the importance of play, I believe that his own research was shoddy at best. Yes, Montessori Shir Hashirim does include direct instruction, but the children also have a great deal of playtime. His ultimate conceit that sending a child to a school where she gets to learn about all sorts of whales might lead to "toxic stress" and hippocampus damage is specious at best.

Tullis's most egregious error is that he seems to have missed the possibility that there are many ways to make education fun. Certainly there is not an expert out there who would recommend *no* education for preschool children: After all, what are we doing when we read to them at night? We are teaching them the basic fundamentals of reading—albeit in a way that is enjoyable for them.

Montessori Shir Hashirim strives to instill a lifelong love of learning in our children. I believe they do that very well. Basically, this school creates future readers of *Scientific American Mind*.

Your poorly argued, offensive article, however, has created an ex-reader of *Scientific American Mind*.

Stuart Gibbs
via e-mail

The debate over direct teaching versus discovery learning through play is not new. Though not always confined to preschool education, this debate is usually centered on the problem of constructing a discovery learning program in which learning can be observed and assessed. The difficulty stems from the demands of managing a classroom with 12 to 20 children while at the same time trying to assess individual learning. Although it can be done, the variability associated with play-based learning is much greater than that associated with direct instruction. Teachers have often not been adequately prepared to admin-

ister and justify play- and activity-based programs and thus have been vulnerable to criticisms of them.

William James Wagner
via e-mail

ABNORMAL EYE MOVEMENTS

Thank you for the fascinating article "Shifting Focus," by Susana Martinez-Conde and Stephen L. Macknik. As a schizophrenic, I imagine that many patients have abnormal microsaccades, meaning that when they follow a target or scan a display their eye movements are accentuated. Perhaps these eye movements explain the phenomenon of the schizophrenic's "mad look."

Greg Westlake
Norfolk, England

MARTINEZ-CONDE AND MACKNIK REPLY: *No previous research has examined the connection between microsaccades and schizophrenia—or any other psychiatric illness. But there has been extensive work showing that people with schizophrenia do indeed have abnormal saccades, the fast eye movements that direct our gaze from object to object as we explore a visual scene. According to neurologists R. John Leigh and David Zee, authors of the comprehensive* The Neurology of Eye Movements *(Oxford University Press, 1999), schizophrenics show consistent abnormalities in the voluntary control of saccades, particularly in tasks requiring imagination, memory or prediction.*

Research suggests that saccades and microsaccades are controlled by the same brain areas, so it seems likely to us that microsaccades also will be found to be abnormal in schizophrenia. Only directed research will provide a definitive answer to this fascinating question.

STORYTELLING

"In the Minds of Others," by Keith Oatley, was an excellent summation of the impact of stories on social skills. This concept has been particularly applicable to the summer camp I run, which allows campers to engage in an interactive storyline with outcomes that change depending on their decisions. We have noticed a high degree of altruistic acts among our kids while they interact with other characters—perhaps because fiction can increase a person's level of empathy, as the article describes.

Human beings have been learning from stories since the brain could grasp fictional concepts. Oral traditions may have evolved into predominately audio-visual or text format, but we still connect on a deeper level with the person who can weave a well-worded story. (Politicians have known this for quite some time.) Shouldn't the educational system embrace this concept? If our summer camp can teach chemistry, history, foreign languages, and more using interactive fiction, I think schools can use stories to better reach their students and engage them in learning.

Meghan Gardner
Director, Wizards & Warriors Camp
Burlington, Mass.

MANY FACES OF GRIEF

I am a great fan of *Scientific American Mind*, but as someone who has worked with the bereaved for more than 20 years, I was dismayed by your article "Grief without Tears," by Hal Arkowitz and Scott O. Lilienfeld [Facts and Fictions]. The authors extrapolate from a particular subset of bereaved people—elderly widows and widowers—to the general population. To equate the predictable loss of a spouse in old age with, for example, the untimely loss of a parent in childhood is cavalier at best, dangerously irresponsible at worst.

One child in five is likely to develop a psychiatric disorder following a parental death. Parental bereavement in childhood has been robustly linked to impaired academic performance, higher rates of teenage pregnancy and drug and alcohol abuse, as well as a range of mental health disorders as adults. Most children and teenagers will experience anxiety, depression and social withdrawal in the first two years after a major loss. Even when distress is not permanent, it is still real and painful and bewildering for the child.

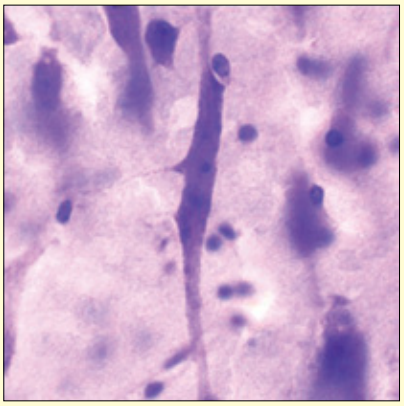
A key protective factor for bereaved children is quality communication with remaining significant adults. Surely we should err on the side of caution and make support available even for those who do not need it.

Rebecca Abrams
Oxford, England

ARKOWITZ AND LILIENFELD REPLY: *Abrams criticizes us for equating the loss of a spouse in old age with the loss of a parent in childhood. We agree that such a parallel is inappropriate; in fact, we made it clear in our article that "grief is not a one-size-fits-all experience."*

She also says that most children and teenagers will experience anxiety, depression and social withdrawal in the first two years after a major loss. Yet these emotional setbacks develop into disorders in only one out of five youngsters. That percentage confirms rather than refutes our central argument: as emotionally devastating as loss can be, resilience following such loss is the norm, not the exception.

ERRATUM The image printed with the story "Suicide Cells," by Charles Q. Choi [Head Lines], was mislabeled. It showed many types of cells, including both von Economo and pyramidal neurons. The correct description is that the von Economo neuron is the long cell in the center of the image below.



COURTESY OF ELISABETH PETRASCH-PARWEZ *Ruhr University Bochum*

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Head Lines

>> BEHAVIOR

License to Sin

People are quick to treat themselves after a good deed or healthy act

Anyone who has ever devoured a triple-chocolate brownie after an intense workout knows how tempting it can be to indulge after behaving virtuously. A new study suggests, however, that we often apply this thought process to inappropriate scenarios, giving ourselves license to act in unhealthy or antisocial ways.

Researchers in Taiwan gave a sugar pill to 74 smokers, misleading half of them to think it was a vitamin C supplement. All the participants then took an unrelated survey and were told they could smoke if they desired. Those who believed they had taken a vitamin smoked twice as many cigarettes as those who knew they had taken a placebo. According to study co-author Wen-Bin Chiou of National Sun Yat-Sen University, the participants may have felt, consciously or unconsciously, that the healthy activity entitled them to partake, a concept known as the licensing effect.

His study, published in the journal *Addiction*, is the first to examine the health ramifications of the licensing effect, but others have shown its influence on moral behavior. In 2009 a study found that reminding people of their humanitarian attributes reduced their charitable giving. Last year another experiment showed that when individuals buy ecofriendly products, they are more likely to cheat and steal.

"Sometimes after we behave in line with our goals or standards, it's as if our action has earned ourselves some moral credit," says psychologist Nina Mazar of the University of Toronto, an author of the green products study. "This credit can then subsequently be used to engage in self-indulgent or selfish behaviors without feeling bad about it."

You may be able to avoid the pitfall simply by remembering that the feeling of having "earned it" leads down a path of iniquity. —*Ashley Welch*

PREFERENCES

I Really Like You

Learning to like somebody may be as easy as saying the words

Saying you are fond of someone might make you actually like that person, according to a study in the October 2011 issue of the *Journal of Experimental Psychology: Animal Behavior Processes.* Psychologists showed 39 students a series of photographs of people who had been previously judged as neither pleasant nor unpleasant and instructed them to say the word "likable" or "unlikable" while viewing each one. Later, the students saw the pictures again in a random order and expressed how they felt about every person. They said they liked people 17 percent more often when they had previously been told to say "likable" compared with when they had said "unlikable." The study used a method that has been shown to circumvent any conscious memories of which image

went with which label; the subjects truly seemed to feel more warmly toward those they called likable. The results are something to consider the next time you politely say you like your boring dinner date or noisy office mate. —*Nathan Collins*

496,000 MILES The distance your brain cells would cover if they

MENTAL ILLNESS

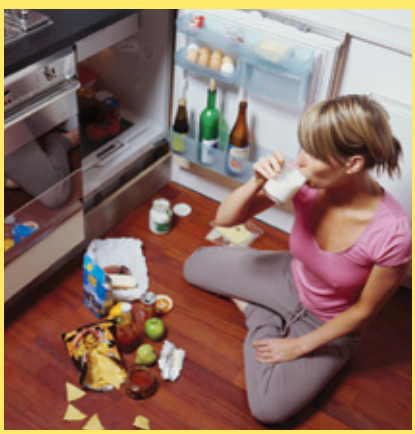
The Cognitive Roots of Binge Eating

Problems with focus and self-understanding are linked to eating disorders

Eating disorders are not just about food. That much has been clear for decades, but researchers are still working to untangle the complex psychological, cultural and physiological roots of afflictions such as binge-eating disorder (BED) and bulimia. Now a growing body of work is finding that disordered eating is connected to attention deficits and poor self-awareness.

In one recent study, psychologists at Geneva University in Switzerland tested the cognitive abilities of three groups—obese individuals with BED, obese individuals without BED and a normal-weight control group. They found that obese participants had difficulties with inhibition and focusing their attention. These cognitive deficits were most severe in the BED group, which points to a "continuum of increasing inhibition and cognitive problems with increasingly disordered eating," the authors wrote in the journal *Appetite* last August.

A different study in the August issue of the *Western Journal of Nursing Research* found that low executive function—the cognitive capacity for self-understanding and self-regulation—is



correlated with both obesity and symptoms of ADHD. And several other studies have linked distraction with overeating. The study found that focusing on one's meal was linked to eating less later in the day—although for someone with ADHD, such focus can prove challenging.

Taken together, these results suggest that treatment for binge eating may need to include strengthening mental functions such as attention and self-awareness.

Exploring the influence of ethnic identity on self-understanding could also help prevent eating disorders, suggests a study last September in the *Journal of Black Studies*. Using surveys, the study found that African-American women with higher levels of ethnic identity were less likely to develop binge eating and bulimia, whereas for Caucasian women, higher levels of ethnic identity posed a greater risk of disordered eating. Study author Mary Shuttlesworth, a doctoral candidate in psychology at the University of Maryland, explains that Caucasian ideals tend to emphasize thinness and focus strictly on appearance, whereas African-American beauty ideals often include "other aspects of the self aside from physical appearance; acceptance of different body shapes and sizes; and allowing beauty to encompass personality, style or attitude." She suggests that prevention programs could focus on building in all people, regardless of race, the elements characteristic of African-American ethnic identity.

—*Tori Rodriguez*

PAUL BRADBURY *Getty Images (top)*; MATTHIAS TUNGER *Getty Images (bottom)*

>> SOCIAL INTERACTION

Life at the Top

Feeling prestigious makes people more trusting

High status confers a rosy worldview, according to research available online last August in *Organizational Behavior and Human Decision Processes*. Psychologists asked college students to write essays about having more prestige than others or being low on the totem pole, thus priming them to think of themselves as having either high or low status. Then the students were told they could send $10 to an unseen partner; the money would be tripled, and the phantom partner would return as much as he wanted. Forty percent of the high-status group sent the $10 versus 12 percent of the low-status group.

The researchers suggest that when a person feels their position garners admiration and respect, they expect to be treated well and so are more willing to trust others. So if you are feeling like you are on the bottom rung—starting a job or interacting with a new group of people, for instance—it may help to remember that those around you are most likely full of trust and positive expectations. *—Harvey Black*

were laid out end to end, stretching roughly to the moon and back.

>> BRAIN DEVELOPMENT

How Packaged Food Makes Girls Hyper

A chemical found in many plastics affects brain development in the womb

The chemical bisphenol A, known as BPA, has become familiar in the past decade, notably to parents searching for BPA-free bottles for their infants. Animal studies have found that BPA, which resembles the sex hormone estrogen, harms health. The growing brain is an especially worrisome target: estrogen is known to be important in fetal brain development in rodents. Now a study suggests that prenatal, but not childhood, exposure to BPA is connected to anxiety, depression and difficulty controlling behaviors in three-year-olds, especially girls.

More than 90 percent of Americans have detectable amounts of BPA in their urine; for most people, the major source of exposure is diet. BPA is a component of the resins that line cans of food and the plastics in some food packaging and drink containers, and the chemical leaches into the edible contents. Other sources of BPA exposure include water-supply pipes and some paper receipts.

Epidemiologist Joe M. Braun of Harvard University and his colleagues studied 240 women and their children in the Cincinnati area. The researchers collected urine samples from the

mothers twice during pregnancy and within 24 hours of birth and from the children at ages one, two and three. BPA was detectable in 97 percent of the samples. They also surveyed parents about their kids' behavior and executive functions—a term for the mental processes involved in self-control and emotional regulation.

The researchers found that the more BPA children were exposed to in the womb, the more anxious, depressed and hyperactive they were at three years old and the more difficulty they had controlling their emotions and inhibiting behaviors. The effects were most severe in girls. The team did not find a connection between the children's behavior and their exposure to BPA after they were born, they report in the November 2011 issue of *Pediatrics*.

Determining the precise mechanisms behind BPA's effect on behavior will require more work, Braun observes. BPA interferes with estrogen; in the brain, this action could affect the migration and survival of neurons, for example. "It is fair to say there is reasonable concern over BPA toxicity," Braun says.

Luckily, reducing dietary exposure is possible. As reported last July in *Environmental Health Perspectives*, 20 participants swapped their normal diet, which included canned and packaged foods, for a "fresh foods" diet, which did not. The dietary switch reduced the participants' BPA levels by 66 percent after three days. *—Aimee Cunningham*

PETER DAZELEY Getty Images (top); GETTY IMAGES (bottom)

>> THEORY OF MIND

The Carnivore's Dilemma

Meat eaters selectively deny mental abilities in the animals they consume

On the savanna a lioness will fell and shred her prey without empathy. Yet for we humans who can imagine that a cow might feel pain, pleasure and fear, enjoying animal flesh may have moral overtones. New research indicates that we have developed a mental tool to help us cope with the realities of our carnivorous nature: denial.

In a study that excluded vegetarians, psychologist Brock Bastian of the University of Queensland in Australia and his colleagues first asked participants to commit to eating either meat slices or apple wedges. Before eating, everyone wrote an essay describing the full life cycle of a butchered animal and then rated the mental faculties of a cow or a sheep. Participants who knew that they would have to eat meat later in the study made much more conservative assessments of the animal mind, on average, denying that it could think and feel enough to suffer. The study was published last October in *Personality and Social Psychology Bulletin*.

"People engage in the denial of mind in animals to allow them to engage in the behavior of eating animals with less negative effect," Bastian says. The researchers argue that although humans have the ability to imagine themselves in someone else's shoes—or hooves—doing so is not always helpful. People living in carnivorous cultures may have developed this strategy of denial to better align their morals with their traditions so they may continue to consume meat without being consumed by guilt.

—Morgen E. Peck

>> ATTRACTION

The Problem with the Pill

Using oral contraceptives may affect relationship satisfaction

Birth-control pills are known to affect women's taste in men, at least in laboratory experiments. Now a study of real-world couples suggests that this pill-related preference change could have long-term consequences for a relationship's quality and outcome.

In the lab, women using oral contraceptives show a weaker preference for masculine men—those with high testosterone levels and the corresponding physical hallmarks—than their non-pill-using counterparts. To investigate this issue in a real-world setting, psychologist S. Craig Roberts of the University of Stirling in Scotland and his collaborators gave online surveys to more than 2,500 women from various countries. According to the results, published online October 12 in the *Proceedings of the Royal Society B: Biological Sciences*, participants who used hormonal contraceptives while choosing their partner were less attracted to him and less sexually satisfied during their relationship than were individuals who did not use hormonal birth control. Pill users were happier with their mate's financial support and other nonsexual aspects of the relationship, however, and they were less likely to separate.

This relationship stability might be caused by the bias of women on the pill toward low-testosterone men, who tend to be more faithful. Roberts suggests that women who met their mate while taking the pill might want to switch to nonhormonal contraceptives several months before getting married to test whether their feelings for their partner remain the same.

—Janelle Weaver

>> HOT AIR

Video games are always a waste of time.

Reality: Some video games can be a good vehicle for training specific skills, such as enhancing short-term memory, agility or reaction time.

ASHLEY JOUHAR *Getty Images (top)*; RYAN LANE *iStockphoto (bottom)*

>> MOOD

Happy in the Morning

Twitter reveals daily emotional rhythms are consistent across cultures

"Happy hour" is not when you might expect it to be, according to a new analysis of about half a billion Twitter messages from around the globe. On average, people are chipper when they wake up and become grouchy as the day wears on. This pattern holds true on weekends, too, but is delayed by about two hours—a trend confirmed in tweets from the United Arab Emirates, where the workweek is Sunday through Thursday. The data suggest that sleep schedules strongly influence mood cycles. The duo at Cornell University who carried out the research, published last September in *Science*, say that the rising popularity of online social media is allowing scientists to study human behavior in surprising new ways. *—Janelle Weaver*

>> CLAIMS & CAVEATS

A larger network of Facebook friends correlates with a greater volume of gray matter in the amygdala, an emotion-processing region, according to a recent study.

BUT: The study could not conclude whether the increased gray matter came from having more friends online or whether having more gray matter wins you more friends.

>> LEARNING

The Oops! Response

Why some people learn more from their mistakes

People who believe intelligence can be boosted with effort are more likely to learn from setbacks and make fewer errors going forward. After a slipup, their brain shows a greater bump in electrical activity, which may represent their desire to self-correct.

Is intelligence innate, or can you boost it with effort? The way you answer that question may determine how well you learn. Those who think smarts are malleable are more likely to bounce back from their mistakes and make fewer errors in the future, according to a study published last October in *Psychological Science*.

Researchers at Michigan State University asked 25 undergraduate students to participate in a simple, repetitive computer task: they had to press a button whenever the letters that appeared on the screen conformed to a particular pattern. When they made a mistake, which happened about 9 percent of the time, the subjects realized it almost immediately—at which point their brain produced two tiny electrical responses that the researchers recorded using electrodes. The first reaction indicates awareness that a mistake was made, whereas the second, called error positivity, is believed to represent the desire to fix that slipup. Later, the researchers asked the students whether they believed intelligence was fixed or could be learned.

Although everyone slowed down after erring, those who were "growth-minded"—that is, people who considered intelligence to be pliable—elicited stronger error-positivity responses than the other subjects. They subsequently made fewer mistakes, too. "Everybody says, 'Oh, I did something wrong, I should slow down,' but it was only the growth-minded individuals who actually did something with that information and made it better," explains lead author Jason Moser, a clinical psychologist at Michigan State.

People who are not so inclined, however, can change their approach, Moser adds. "A growth mind-set is about focusing on the process—as in the experience—rather than only on the outcome," he says. "Setbacks are opportunities to gain information and learn for the next time, so pay attention to what went wrong and get the information you need to improve."

—Melinda Wenner Moyer

ANDREW RICH Getty Images (top); DON MASON Corbis (bottom)

>> VISIONS

Mouse Neuron

A mouse's nerve cell has broken open to showcase vibrantly colored sacs, which house its neurotransmitters, the chemical messengers neurons use to communicate with one another and with other cells.

>> MEDICINE

Defeating Pain without the Itch

A frustrating side effect of some painkillers is finally explained

Millions of patients benefit from opioids such as morphine and codeine, but the pain relief they provide often comes with intense itching. In some cases, the irritation is so bad that patients will opt to cut back on painkillers. Now a study in the October 14 issue of *Cell* has found a possible explanation—the first step to creating drugs that will not make patients choose between experiencing itchiness and pain.

Until recently, many experts had assumed that itching from opioids was unavoidable because it is a common side effect of drugs that interact with the nervous system. The brain has four main types of receptors that respond to opioids, and every type has many structural variants, called isoforms. Most opioids are nonspecific, which means they bind to all the isoforms. This leads to powerful pain relief, although scientists do not know exactly why.

In the new research, a team led by itch researcher Zhou-Feng Chen of Washington University in St. Louis showed that only one opioid receptor isoform is responsible for itching—and it is not involved in pain. Mice bred to have fewer of these particular receptors did not scratch themselves when given an opioid, but they did exhibit the telltale mouse signs of pain relief, such as less flinching when researchers flicked their tails.

Now that scientists know that pain relief and itching can be decoupled, they will try to make itch-free opioid drugs a reality.

—Erica Westly

TINA CARVALHO *Getty Images (top)*; GETTY IMAGES *(bottom)*

>> FOOD FOR THOUGHT

An analysis of one million students in New York showed that those who regularly ate lunches with no artificial flavors, preservatives or dyes did better on IQ tests than students who ate lunches with additives.

>> OUTLOOK

Unflagging Optimism

Why adjusting our expectations to reality is so difficult

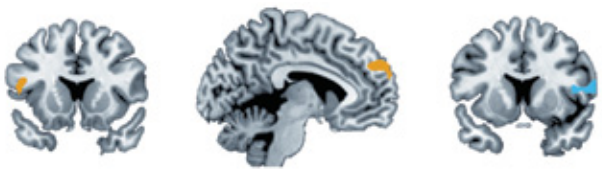
Most of us hold unrealistically optimistic views of the future, research shows, downplaying the likelihood that we will have bad experiences. Now a study in *Nature Neuroscience* last October has found clues to the brain's predilection for the positive, identifying regions that may fuel this "optimism bias" by preferentially responding to rosier information.

Tali Sharot, a University College London neurology researcher, and her colleagues asked 19 individuals between the ages of 19 and 27 to estimate their odds of experiencing 80 unfavorable events, such as contracting various diseases or being the victim of a crime. Participants were then told the actual average probability of each before repeating the exercise.

The participants revised most of their estimates the second time around, but 79 percent of those tested paid much more attention when their actual risk was lower than what they had initially guessed. After getting the good news, these subjects rated their risk for these events as significantly lower than they did earlier. In contrast, when they had underestimated their odds of meeting with a particular misfortune, they made less drastic revisions to their guess or none at all—clinging to their earlier belief that they would probably avoid the bad luck.

Using functional MRI, the researchers found areas in the prefrontal cortex, where conscious reasoning takes place, that were active when participants received information that was better than anticipated. The greater the difference between the subjects' initial guess of their risk and the true probability, the more activity appeared in these regions, hinting that they contribute to positive error correction.

Activity in another part of the brain, the right inferior frontal gyrus, changed in response to discouraging information. There, however, activity did not correspond as closely with the magnitude of error in the participants' initial risk estimates, matching the poorer correction later. That inconsistent neural response was observed most clearly or most often in individuals who scored higher on standard tests for optimism as a personality trait.



Areas in the prefrontal cortex (*yellow*) spring to action when we learn our risk of misfortune is lower than we thought. If the risk is higher, the right inferior frontal gyrus (*blue*) responds.

This finding jibes with past studies that observed an optimism bias in about 80 percent of the population. Its absence can signal anxiety or depression. Yet being overly optimistic has consequences, too, Sharot says, preventing us from taking some precautions to avoid harm or misfortune. Realizing the brain's partiality may be half the battle. "If you are aware of the optimism bias, you can commit to actions or rules that will help protect you," Sharot notes.

—Andrea Anderson

FROM "HOW UNREALISTIC OPTIMISM IS MAINTAINED IN THE FACE OF REALITY," BY TALI SHAROT, CHRISTOPH W. KORN AND RAYMOND J. DOLAN, IN *NATURE NEUROSCIENCE*, VOL. 14; 2011

>> MIND-BODY CONNECTION

How Exercise Jogs the Brain

Physical activity boosts cognition by improving neurons' power supply

The lifelong mental benefits of exercising have long been known, from improving learning in kids to staving off dementia in seniors. Yet how working up a sweat leads to better cognition is much less clear. A study in the *Journal of Applied Physiology* reveals that the key may lie in the body's power supply.

Just as a booming metropolis might build new power plants to meet a rising need for electricity, our muscles respond to the demands of exercise by producing new mitochondria, the tiny structures inside cells that supply the body with energy. J. Mark Davis, a physiologist at the University of South Carolina, and his colleagues wondered if brain cells might do the same thing. While studying mice, they found that quantities of a signaling molecule, dubbed by researchers "a master regulator" of mitochondria production, increased in the brain after half an hour a day of treadmill running. The mice's brain cells also had more mitochondrial DNA—distinct from the regular cellular DNA found in the nucleus—providing "gold standard" evidence of more mitochondria. It appears that the brain "adapts and changes by bringing more of these powerhouses" online, Davis says. The increased energy supply allows the brain to work faster and more efficiently.

The finding could help scientists understand how exercise staves off age- and disease-related declines in brain function, because neurons naturally lose mitochondria as we age, Davis explains. Although past research has shown that exercise encourages the growth of new neurons in certain regions, the widespread expansion of the energy supply could underlie the benefits of exercise to more general brain functions such as mood regulation and dementia prevention. "The evidence is accumulating rapidly that exercise keeps the brain younger," Davis says.

—Stephani Sutherland

>> CHILD DEVELOPMENT

Baby Justice

Infants may understand fairness and sharing earlier than expected

Well before "not fair!" becomes a staple phrase of your child's spoken repertoire, he or she might already have a fundamental grasp of right and wrong. A study published last October in *PLoS One* found that 15-month-old infants could identify unequal distributions of food and drink and that this sense of fairness was connected to their own willingness to share.

To measure these moral sentiments, researchers first had the children watch movies of an actor distributing food, either equally or unequally, between two people. Most of the toddlers spent more time looking at the unequal outcome, suggesting it surprised them by violating their basic sense of fairness. Next, every child picked his or her favorite of two new toys, and the researchers then asked the kids to share one of the toys. Of the infants who shared their favorite toy, 92 percent had also been surprised by the unfair outcome in the videos.

Scientists have typically thought that other-regarding preferences—which may have played an important role in the evolutionary history of human cooperation—emerge in early or mid-childhood, around the ages of seven or eight. This study suggests that they may develop as early as the second year of life and that those early moral judgments and behaviors are more closely intertwined than ever expected.

—Lena Groeger

>> HEAD COUNT

130 MILLISECONDS

The amount of time that elapses between when a driver intends to brake and when he or she actually hits the brakes, as measured by electrodes monitoring brain activity of subjects in a driving simulator.

(A car going 60 mph will travel 12 feet in that time.)

BRAIN CHEMISTRY

Double-Edged Hormone

A promising target for mood drugs turns out to both cause and relieve anxiety

If you have ever jumped at a loud noise and felt an adrenaline rush, you have experienced the effects of corticotropin-releasing hormone (CRH). In the body, this hormone triggers the familiar fight-or-flight response—racing heart, shortness of breath, sweaty palms. In the brain, however, it acts as a chemical messenger, playing a role in anxiety and depression. That role, a new study suggests, is more complex than anyone expected.

Because animal research from the past decade found that CRH contributes to anxiety and depression, drugs were developed that would block its actions in the brain. Clinical trials of these anti-anxiety and antidepressant drugs in human patients, however, have been disappointing. The new study, published last September in *Science*, shows why. Jan M. Deussing, a molecular biologist at the Max Planck Institute of Psychiatry in Munich, and his colleagues genetically altered mice so that some of their brain cells would be unable to detect the presence of CRH because they lacked the proper receptors. When the receptors were missing from neurons that produce the neurotransmitter glutamate, the mice displayed less anxiety, as expected. Yet when the receptors were missing from neurons that produce dopamine, the mice became more anxious.

These two different neuron types, when interacting with CRH, "have exactly opposite effects in terms of anxiety-related behavior," Deussing says. Because the unsuccessful drugs limited the amount of the hormone available to all types of neurons, they ended up blocking its actions at neurons that both produce and prevent anxiety. The finding reaffirms scientists' growing understanding that mood disorders do not result from a simple chemical imbalance—too much or too little of one neurotransmitter—but rather from subtle changes in many systems in the brain. "The network is much more complex than we thought before," Deussing says.

—Stephani Sutherland

SEXUALITY

It's Not Me, It's Us

New findings point to relationship issues as the primary cause of female sexual dysfunction

Formerly known as frigidity, female sexual dysfunction (FSD) has always been a controversial diagnosis, and now studies are pointing to relationship dissatisfaction and male performance as risk factors. Just whose problem is this, anyway? New research suggests that broad tactics such as treating a woman's anxiety and improving communication with her partner may be more useful than focusing on the physical mechanics of sex.

Female sexual dysfunction is a broad diagnosis that indicates trouble in one or more of four areas: desire, pain, arousal and orgasm. Controversy about FSD has centered on two key points: whether those who are pushing it as a physiological disorder have something to gain from medicalizing it and whether it reflects society's attempt to pathologize women's naturally variable sexuality. According to sexologist Andrea Burri, author of a study from the U.K. on FSD that appeared in the September 2011 issue of the *Journal of Sexual Medicine*, "Describing a sexual dysfunction as a physiologically caused abnormality leaves out factors related to the patient's sexual partners and socialization factors. Personally, I believe that we are using the term way too arbitrarily." Although she accepts that some women do have a physiological impairment that can contribute to sexual problems, she thinks that using loose diagnostic criteria lumps far too many women into the category of dysfunction.

Burri's study, which assessed about 1,500 women in the U.K. for FSD, found that 5.8 percent of them reported recent problems with sex, and another 15.5 percent reported lifelong dysfunction. Hyposexual (low) desire was the most common problem overall, and the most common predictor of FSD was relationship dissatisfaction. This finding supports the criticism that the concept of FSD is misleading because it implies that there is something wrong with the woman who "has" it, when in fact it is often the relationship that has issues. The study also found anxiety, experience of abuse and obsessive-compulsive disorder to be common predictors of lifelong FSD.

A study last June also pointed to relationship dissatisfaction as a risk factor for FSD, as well as male premature ejaculation—so in this case, his dysfunction becomes hers, further obscuring the diagnosis.

One way researchers are attempting to minimize some of these issues is by including personal distress as a diagnostic criterion for FSD. Pain during sex or a lack of desire, arousal or orgasm does not indicate a disorder unless it is causing distress to the woman herself—and that does not include the distress she might feel because of her partner's reaction in bed, explains Marita McCabe, a psychology professor at Deakin University in Melbourne, Australia. Burri cautions that the distress criterion nonetheless presents some concerns. "A considerable proportion of women who do not report a sexual problem do report feeling distressed about their level of sexual functioning, so there is the question as to what causes a woman to feel sexual distress," she says. "Is it really an intrinsic feeling, or is it caused by societal expectations?"

Regardless of its cause, distress about sex is quite treatable. McCabe authored a study last October showing Internet-based therapy to be effective for FSD when it focused on three objectives: helping participants feel more comfortable about their bodies, lowering their anxiety in sexual situations and improving communication with their partners.

—Tori Rodriguez

HOT AIR

More synapses mean more brainpower.

Reality: Infants have a higher density of synapses than adults, but adults are more knowledgeable by far.

BRAINPOWER

Simply thinking about exercise can improve your health.

People who imagine flexing a muscle increase both their brain activity and muscle strength, according to researchers at the Cleveland Clinic Foundation.

JUSTIN HORROCKS /*Stockphoto*

Urban Illusions

Street artists use the city as their canvas

BY SUSANA MARTINEZ-CONDE AND STEPHEN L. MACKNIK

The life of our city is rich in poetic and marvelous subjects. We are enveloped and steeped as though in an atmosphere of the marvelous; but we do not notice it. —Charles Baudelaire, 1846

URBAN LANDSCAPES are embodiments of human aspirations and dreams. They represent the spirit of an age and personify the minds and hearts of the people who inhabit them. Archaeological excavations of ancient cities, such as the magnificently preserved ruins of Pompeii and Herculaneum, bring to life our distant past. If we could peer into the future, we would want to know what our cities will look like to understand who we will become.

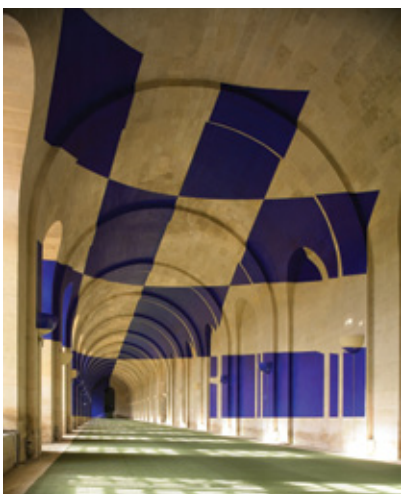
Cities capture our imagination in fascinating ways. Art and folklore are chock-full of mythical and imaginary cities, from the sunken lost city of Atlantis and El Dorado's city of gold to Fritz Lang's dystopian film *Metropolis* and, more recently, the Escheresque architecture of the folding cityscapes in the movie *Inception*. Yet we need not turn to fiction or travel far in space or time to experience the wonder. Even the most desolately functional urban environments can be sprinkled with nuggets of magic and surprise, with illusion "Easter eggs" that challenge our perception of what's real.

Our everyday cities are not all that they may seem. Oftentimes it's a matter of perspective. **M**

SUSANA MARTINEZ-CONDE and STEPHEN L. MACKNIK are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors of the 2010 *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee, now in paperback (http://sleightsofmind.com). Their forthcoming book, *Champions of Illusion,* will be published by Scientific American/Farrar, Straus and Giroux.

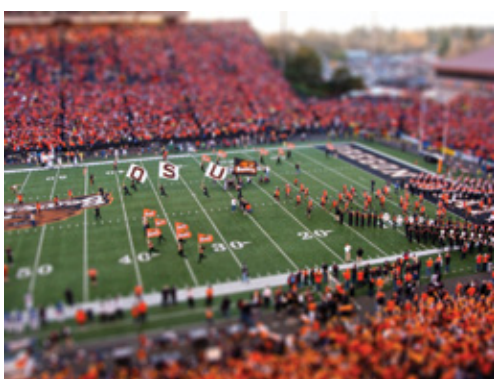
PHANTOM SHAPES

Several artists use anamorphosis, a type of perspective that relies on a particular vantage point. Phantom stairways to heaven (*below*) and other geometric figures (*right*) haunt the observer. Move a few steps to the side, however, and only fragmented shapes remain. These artworks are dramatic examples of the perceptual organization principle that Gestalt psychologists called good continuation: we tend to group visual elements that suggest an unbroken or continued line. Neuroscientist Charles D. Gilbert and his colleagues at the Rockefeller University found a neural basis. Neurons in the primary visual cortex are tuned to specific edge orientations; they prefer, say, horizontal line segments or vertical ones. Your brain can integrate information well beyond the boundaries of single neurons, however. It turns out that neurons with similar orientation preferences are connected via horizontal fibers that travel long distances in the primary visual cortex. These long-range connections among similar types of neurons allow your mind's eye to "see" the ladder instead of disjointed shapes.



HAUNTED HOUSE

Projection mapping is a recent technique for artistic expression, which provides the illusion of movement in stationary objects such as large buildings. The 3-D aspects of the end product are equally remarkable. By adding shading and subtle size changes to the projected objects, the artists induce a powerful feeling of depth and volume that our visual neurons can't resist. This piece, produced by Urbanscreen and projected on the Galerie der Gegenwart at the Hamburger Kunsthalle art museum in Germany, is entitled *How It Would Be if a House Was Dreaming*. Watch the video at www.urbanscreen.com/usc/41.



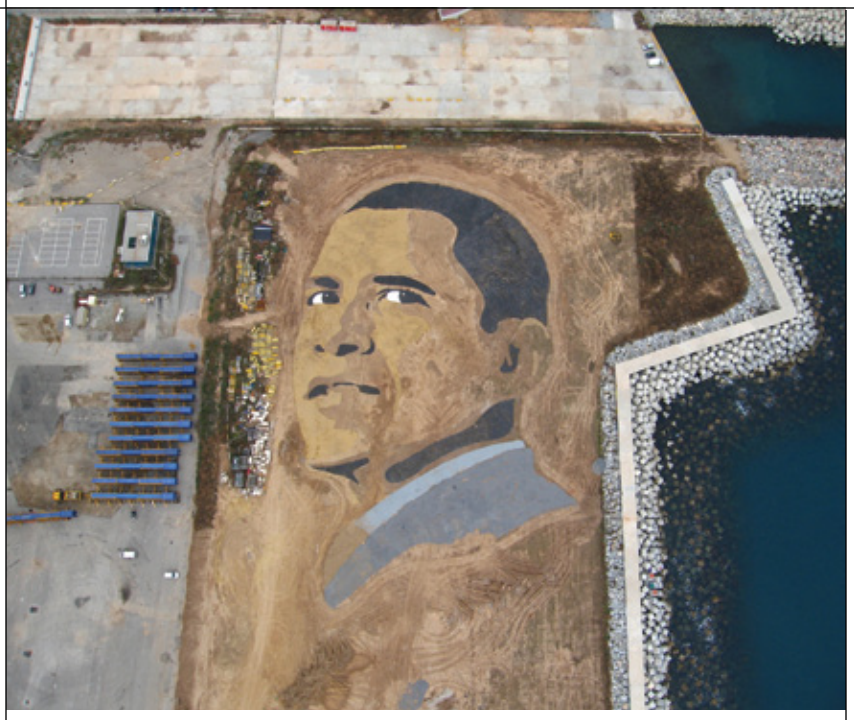
HONEY, I SHRUNK THE STADIUM

We turn from the massive to the minute. Miniature faking via digital postprocessing can turn a crowded stadium into a game of foosball. In this technique, a small selected portion of the image remains sharp, whereas the other regions are blurred to various degrees, simulating the shallow depth of field of close-up photography. The resultant image looks like the photograph of a miniature scale model, rather than an actual scene.

AN INVISIBILITY CLOAK OF PAINT

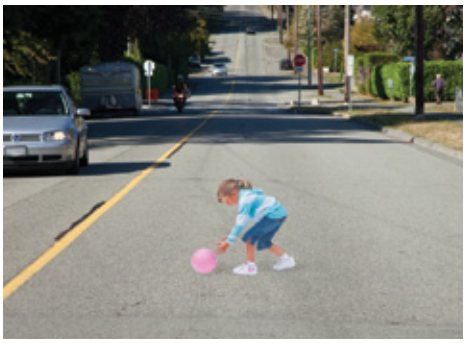
Some illusions make objects appear, such as floating ladders and squares. Others make objects disappear. Sara Watson, then a student at University of Central Lancashire in England, devised a spectacular vanishing act as part of her drawing and image-making course. She gave an old Skoda a new paint job that made it invisible by allowing it to blend in with the background like a chameleon. Urban camouflage at its finest.

COURTESY OF URBANSCREEN (*top*); COURTESY OF GREG KEENE (*left*); COURTESY OF UNIVERSITY OF CENTRAL LANCASHIRE (*right*)



LARGER THAN LIFE

Artist Jorge Rodríguez-Gerada used the smallest materials, grains of sand, to create *Expectation,* a gargantuan portrait of Barack Obama spanning 2.5 acres of beachfront in Barcelona. The president's likeness is imperceptible at human eye level, but from a bird's-eye view the picture comes alive. Sandpainting—especially at a gigantic scale—is a form of pointillism, the technique used by painters such as Georges Seurat, Paul Signac and Vincent van Gogh, in which the juxtaposition of multiple individual points creates patterns and shades of color that become apparent only from afar. The illusion works as long as the image of every element (dot of paint, grain of sand) on the retina is roughly equal to the size of a photoreceptor. Our retina sees the world as a field of photoreceptor points of light, whether they were drawn that way or not, which makes viewing distance critical to our perception of texture. The fine details of wood grain and other textures are visible only up close, when they fall directly on our fovea, the central region of each of our retinas where photoreceptor density is highest. Our photoreceptors are unable to resolve the subtle differences in color or shape of an object when we step away, so the coarser features of the image dominate our perception instead.



CHILDREN CROSSING

One practical application of anamorphic perspective is roadway writing. The abnormally elongated shape of warnings such as "children crossing" allows drivers to read them easily as they approach the text. British Columbia–based safety-awareness group Preventable has pushed this concept to the limit, hoping to change drivers' attitudes in a guerrilla marketing campaign. The group's 45-foot illusion, which portrays a young girl chasing a ball across a busy intersection, stayed for a week near a school in West Vancouver. When drivers approached the image, the girl's shape started to form from about 50 feet away and remained three-dimensional for another 40 feet. You can see the video at www.preventable.ca/2010/09/shifting-attitudes-with-illusions.

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COURTESY OF JORGE RODRÍGUEZ-GERADA www.jorgerodriguezgerada.com (*left*);
COURTESY OF COMMUNITY AGAINST PREVENTABLE INJURIES (*right*)

Shopping for Love

Speed dating and other innovations in matchmaking can confound even the most focused dater, but simple tips can help

BY SANDER VAN DER LINDEN

NINO MASCARDI *Getty Images*

AS A PSYCHOLOGIST, I have always found the concept of speed dating fascinating. During a series of mini dates, each spanning no more than a couple of minutes, participants in a speed-dating event evaluate a succession of eligible singles. They make split-second decisions on matters of the heart, creating a pool of information on one of the more ineffable yet vital questions of our time—how we select our mates.

The concept of rapid-fire dating has gained tremendous popularity, spreading to cities all over the world. One speed-dating company in New York City, for example, holds a gathering almost every day. Last year online coupon company Groupon hosted the world's largest speed-dating event, with 414 attendees crammed into a restaurant in Chicago. Start-up companies now meet with investors, pregnant couples interact with doulas, and homeless dogs court potential owners, all using the speed-dating format.

Some years ago I caved to my curiosity and tried it out myself. As it turns out, I like to talk—a lot. When the little buzzer went off after three minutes, I often found myself still trying to explain to my bedazzled dating partner why my last name has four syllables (it is Dutch). As you might imagine, I did not find the love of my life.

I made some beginner's mistakes; however, I am not alone in having struggled with speed dating. Even if meet-and-greet matching events might seem like the most efficient way to comb through many options at once, a wealth of data reveals that the context in which we make a choice weighs heavily on the outcome. Speed-dating events can promote a particular decision-making style that might not always work in our favor. Yet we need not be passive victims of our circumstances. Knowing how your environment influences your mind-set, a quality known as ecological rationality, can help you make the choices that are best for you.

Decisions, Decisions

Traditional dating can seem haphazard, contingent on seemingly minor details such as whether you signed up for the right yoga class or patronized the same bar as your future love interest. Online dating, too, has its drawbacks, requiring hours to sift through profiles and craft careful introductory e-mails before arranging to meet in person. Speed dating, by comparison, offers the opportunity to chat up many eligible singles in rapid succession.

In a typical speed-dating event, participants pair off at individual tables and chairs for a few minutes of conversation. When the buzzer sounds, half of the singles move to another chair and a different partner, in a kind of round robin. After the event is over, the daters submit to the event's organizers the names of the individuals they would like to see again. It sounds simple, but each variable in the design of the event can affect the daters' outcomes.

In spite of maxims about so many fish in the sea, for example, recent research tells us that the heart prefers a smaller pond. In a study in 2011 in the journal *Biology Letters*, University of Edinburgh psychologist Alison P. Lenton and University of Essex economist Marco Francesconi analyzed more than 3,700 dating decisions across 84 speed-dating events. The authors found that when the available prospects varied more in attributes such as age, height, occupation and educational background, people made fewer dating proposals. This effect was particularly strong when individuals were faced with a large number of partners. Additionally, in speed-dating events where the characteristics of the daters varied much more, most participants did not follow up with any of their matches.

Results observed in the world of online dating support this finding. A study in 2008 by Lenton and Barbara Fasolo of the London School of Economics and Political Science indicates that participants often

misjudge how the number of options available to them will affect their feelings. Participants presented with a broad array of potential partners more closely aligned with their anticipated ideal did not experience greater emotional satisfaction than when presented with fewer options.

search goods include laundry detergent and vitamins. Other desirables can be identified only through an interaction; these "experience goods" encompass movies and puppies.

In a study published in 2008 psychologist Dan Ariely of Duke University and his colleagues set out to demonstrate that when it comes to dating, people are the ultimate experience goods. They asked 47 single men and women to list the qualities they look for in people they would consider either marrying or dating. Independent evaluators then rated the characteristics as either searchable or experiential. In both conditions, men and women mentioned more experiential traits—nearly three times more for dating partners and almost five times more for spouses.

Ariely and his co-authors argue that criteria such as "the way someone makes you laugh" or "how your partner makes you feel good about yourself" are harder to define in an online profile than a fondness for kittens, baseball or crème brûlée, leading people to make judgments based on searchable characteristics. They note that using attributes such as weight and height to choose a partner is similar to trying to predict the taste of a food based on its fiber content and calories. A similar argument could be made for speed dating, in which the conversation can resemble an interview more than a fun experience.

In an upcoming book, Lenton, Fasolo and their colleagues summarize the key message of recent research: how we end up choosing our wives, husbands, boyfriends and girlfriends is a function of the social environment in which the decision is made. To conserve both mental exertion and time, we judge potential partners by comparing them with others we have encountered rather than by measuring them against some cognitive ideal. In a 2006 study, for example, Raymond Fisman of Columbia University and his colleagues showed that when participants in a speed-dating event were asked what they seek in a potential partner, their answers did not match what they ended up finding attractive during the event. What we select depends on what else is being offered.

> We judge potential partners by comparing them with others rather than by **measuring them against a cognitive ideal.**

Prior research by Lenton and Francesconi provides some insight into why people might struggle with speed dating. They found that when the number of participants in a speed-dating event increases, people lean more heavily on innate guidelines, known as heuristics, in their decision making. In essence, heuristics are ingrained rules of thumb that allow us to save effort by ignoring some of the information available to us when we evaluate our options. For example, in those events with a relatively large number of participants, the researchers discovered that people attend predominantly to easily accessible features, such as age, height, physical attractiveness, and so forth, rather than clues that are harder to observe, for example, occupation and educational achievement.

These rules of thumb are evolutionarily adaptive, however, and not necessarily a bad thing. Millions of years of experimentation with different heuristics, conducted in a range of environments, have led us to learn which ones are most effective. Very generally speaking, good looks and youthful vigor are indeed useful metrics for mating because they signal health. Yet if lifelong love is what you are after, a smorgasbord of singles might propel you to make stereotypical selections.

Know Your Environment

One problem with both speed dating and online dating may arise from how we hunt for the things we want. Some items can be found with a simple search targeted at objective qualities. So-called

Becoming aware of that malleability in our taste, and gaining control over our decision-making strategies in response, is known as ecological rationality. It is equally important when choosing between jams at the grocery store and partners to date; the only difference is the stakes.

If you do attempt speed dating, avoid static, standardized conversations. Annual income and body mass index, after all, cannot give you that warm, fuzzy feeling inside. To obtain more experiential information, try telling a joke or casually mentioning that you plan to go, say, bungee jumping next month to see how he or she reacts. Perhaps if I had been more ecologically rational a few years ago, my speed-dating experience would have been more successful as well. **M**

SANDER VAN DER LINDEN is a doctoral student in applied social and environmental psychology at the London School of Economics and Political Science.

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Consciousness Does Not Reside Here

Psychology and functional brain imaging disentangle two closely related processes, attention and consciousness

BY CHRISTOF KOCH

CHRISTOF KOCH (*Koch*); JOHN RENSTEN *Getty Images (this page)*; FROM "ATTENTION BUT NOT AWARENESS MODULATES THE BOLD SIGNAL IN THE HUMAN V1 DURING BINOCULAR SUPPRESSION," BY MASATAKA WATANABE ET AL., IN *SCIENCE*, VOL. 334; NOVEMBER 11, 2011. REPRINTED WITH PERMISSION FROM AAAS (*opposite page*)

WHAT IS THE RELATION between selective attention and consciousness? When you strain to listen to the distant baying of coyotes over the sound of a campsite conversation, you do so by attending to the sound and becoming conscious of their howls. When you attend to your sparring opponent out of the corner of your eye, you become hyperaware of his smallest gestures. Because of the seemingly intimate relation between attention and consciousness, most scholars conflate the two processes.

Indeed, when I came out of the closet to give public talks on the mind-body problem in the early 1990s (at that time, it wouldn't do for a young professor in biology or engineering who had not even yet attained the holy state of tenure to talk about consciousness: it was considered too fringy), some of my colleagues insisted that I replace the incendiary "consciousness" with the more neutral "attention" because the two concepts could not be distinguished and were probably the same thing anyway. Two decades later a number of experiments prove that the two are not the same.

Stage magicians are superb at manipulating the audience's attention. By misdirecting your gaze using their hands or a beautiful, bikini-clad assistant, you look but don't see, inverting Yogi Berra's famous witticism, "You can observe a lot just by watching." Scientists can do the same, sans the sexy woman. I described a psychophysical technique called continuous flash suppression in an earlier column [see "Rendering the Visible Invisible," October/November 2008], in which a faint image in one eye—say, an angry face in the left eye—becomes invisible by flashing a series of colorful overlaid rectangles into the other eye. As long as you keep both eyes open, you see only the flashed pictures. Attention is drawn to the rapidly changing images, effectively camouflaging the angry face. As soon as you wink with the right eye, however, you see the face. This technique has been used to great effect both to hide things from consciousness—such as a naked man or woman—and to demonstrate that the brain will still attend to them.

A Japanese-German collaboration has moved such an experiment into the confines of a magnetic scanner to record the brain's response to unseen stimuli. Rather than using erotic pictures, they projected a low-contrast grating that was drifting horizontally into one eye [*see box on opposite page*]. It was surrounded by a scintillating ring in the same or in the opposite eye. In the latter case, the central stimulus became perceptually invisible. It disappeared. This experiment used what is known in the lingo as a 2×2 design. The scientists manipulated the visibility of the moving grating (two conditions); they also manipulated whether or not subjects attended to the grating (two conditions). They achieved the latter two conditions by asking them to monitor a series of single letters that appeared on the ring and to report the presence of a particular letter. On the other half of the trials, subjects were told to ignore these letters. In total, four conditions were tested.

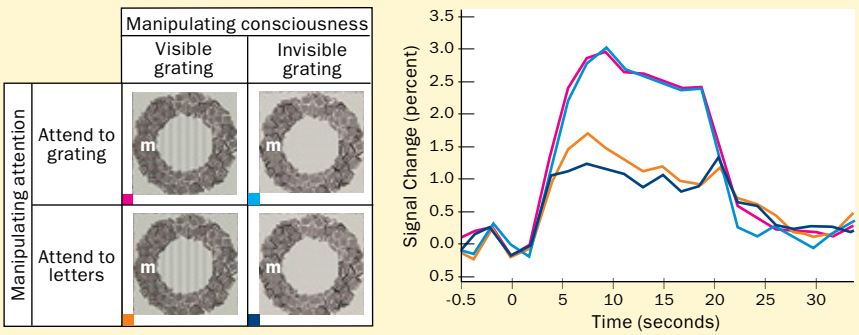
Note that the layout on the monitor always contains the same elements with the ring being projected into the same eye as the moving grating or the opposite eye, et cetera. The key difference was in the minds of the volunteers whose brains

Consciousness and attention are not the same, and the **brain responds differently** to them.

Separating Attention from Consciousness

In an experiment (*below*), a low-contrast grating that was drifting horizontally was projected into one eye; it was surrounded by a scintillating ring in the same or opposite eye. In the latter case, the central stimulus—the grating—became invisible to the subject's conscious awareness. Subjects were asked to attend to either the grating or a letter superimposed on the ring. By testing four different conditions, scientists could manipulate whether the volunteer consciously saw the grating.

Whether or not the volunteer was consciously aware of the grating (*below*), the brain responded to it, as activity in the primary visual cortex revealed by functional MRI shows. But if the subject attended to letters rather than grating, the response was much reduced. The plots indicate the time course of the signal for the four different perceptual conditions: grating visible (*magenta*) or invisible (*cyan*) and attended (*upper two curves*) or grating visible (*orange*) or invisible (*dark blue*) and not attended (*lower two curves*). —*C.K.*



were scanned—whether or not they consciously saw the grating (which they had to report) and whether or not they attended to it.

The cognitive neuroscientists measured the brain's functional MRI response in the primary visual cortex (or V1) in the brain's posterior. Roughly the area of a credit card, this part of the brain receives visual input from the eye. It is the first of 30 or more regions in the cortex that deal with visuomotor behaviors and visual perception.

The data from the seven participants were unambiguous. Paying attention to the target consistently and strongly increased the fMRI activity, regardless of whether the subject saw the target or not. This result was expected because many previous studies had shown that attending to a signal reinforces its representation in the cortex. Much more intriguing, though, was that whether or not the stimulus was consciously perceived made no difference to signal strength [*see box above*]. Visibility didn't matter to V1; what did was whether or not selective visual attention focused on the grating. Indeed, the experimentalists could not decode from the signal whether or not the subject saw the stimulus.

I am very pleased by their finding because it is fully in line with the hypothesis that Nobel laureate Francis Crick and I advanced in 1995. Writing in *Nature*, we had argued that neurons in V1 do not directly contribute to visual consciousness. Our speculation was based on the absence of a direct connection between cells in V1 and their partners in the frontal lobe in macaques. The fMRI experiment described here provided evidence for our conjecture. Whether or not our connectional argument is valid remains open, of course.

It appears that the habitat of consciousness is not the cortical region at the bottom of the extended hierarchy of cortical areas dedicated to vision. Consciousness is restricted to higher regions, possibly those that are engaged in a reciprocal, two-way communication with the prefrontal cortex, the seat of planning.

The history of any scientific concept—energy, atom, gene, cancer, memory—is one of increased differentiation and sophistication until it can be explained in a quantitative and mechanistic manner at a lower, more elemental level. These and related experiments put paid to the notion that consciousness and attention are the same. They are not, and the brain responds differently to them. This distinction clears the decks for a concerted, neurobiological attack on the core problem of identifying the necessary causes of consciousness in the brain. M

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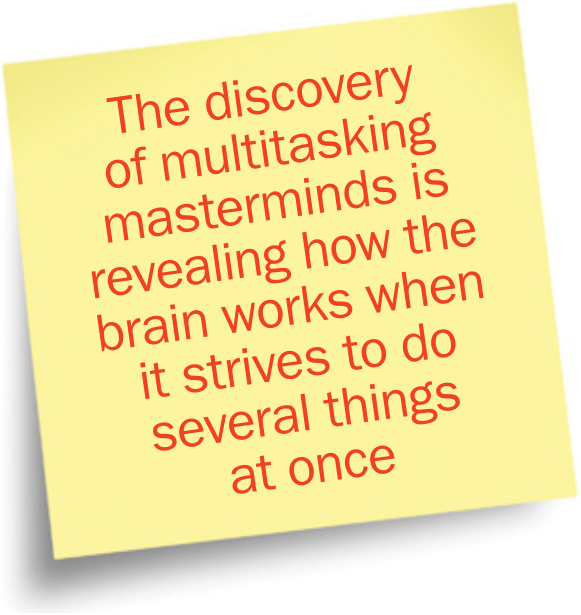
SUPERTASKERS AND THE MULTITASKING BRAIN



"Any man who can drive safely while kissing a pretty girl is simply not giving the kiss the attention it deserves," Albert Einstein is purported to have said. The quote acknowledges a fundamental characteristic of human attention. Sometimes there simply is not enough of it to go around.

Never mind the buzzes and beeps of every new text message and e-mail, distracting as they may be. The pressures to be supportive family members, lifelong learners, chiseled athletes and professional leaders make multitasking nearly irresistible.

By David L. Strayer and Jason M. Watson

ISTOCKPHOTO (*note*); PHOTOILLUSTRATION BY AARON GOODMAN

Daniel Broadbent, a pioneering psychologist who first characterized attention as a limited commodity, was inspired by watching pilots manage overwhelming amounts of information.

You can almost hear our collective inner monologue: there must be a way to trick time, to coerce that lengthy to-do list to start shrinking twice if not three times as fast.

Yet effective multitasking is a myth. So, too, is the idea that members of the "multitasking generation," who grew up with video games, smart phones and e-readers, can somehow concentrate on several things at once. In fact, research indicates that frequent multitaskers are often the *worst* at it.

That multitasking compromises performance has been known for decades. Only now, however, are we beginning to identify some of the personality traits most commonly associated with the most flagrant job jugglers. To our surprise, we have also discovered that a small fraction of the participants in our studies appear to multitask with ease, performing cognitive feats we had not thought possible. These unique individuals have not only given us new insight into the neural mechanisms for managing multiple mental activities, they are also forcing us to rethink our theories of attention.

FAST FACTS

Multitasking Demystified

1» Attempting to complete two or more tasks at once causes us to divide our attention, so that we focus less on each of those activities.

2» A person who drives while talking on a cell phone, for example, is a worse driver than an individual at the legal limit of alcohol intoxication.

3» A small percentage of the population defies this trend and multitasks with ease. These so-called supertaskers are helping to elucidate the underlying brain mechanisms supporting multitasking and attention.

Know Your Limits

The human mind's limited capacity for attention became strikingly apparent with the growth of aviation during World War II. As the task of piloting an airplane increased in complexity, the amount of information that the pilot was required to process also grew—and so did the number of airplane accidents unrelated to mechanical failures. The pioneering psychologist Donald Broadbent set out to investigate whether pilots were able to take in all the information displayed to them. Through his experiments, Broadbent found that the mind of a pilot could take in only a limited number of signals. This premise of finite attention is now a cornerstone for contemporary cognitive neuroscience, and today it is well accepted that attention is limited in capacity and can be flexibly allocated among concurrent tasks.

By this theory, however, devoting more attention to one activity necessarily implies taking it away from others. Attention is thought to amplify some signals and suppress others, two processes known as facilitation and inhibition. If your brain were a dashboard, facilitation and inhibition would be knobs that turn up the volume on relevant stimuli and tamp down extraneous sensations. Tuning attention appropriately is key to healthy cognition, and several psychological disorders stem from the failure to do so, either from difficulties amplifying the appropriate input from your eyes, ears and other senses or from trouble suppressing unimportant details of the environment. In some cases, excessive multitasking may even exacerbate attention-related psychological disorders.

For the past decade our laboratory has been investigating the phenomenon by examining how we balance driving and talking on a cell phone, a common if ill-advised habit of many people. The findings are clear: our performance deteriorates drastically when we attempt to focus on more than one task at a time. Although our interest is in higher-level cognitive activities that compete for attention, even simple acts such as walking and chewing gum

GETTY IMAGES

can be impaired with sufficient cognitive load. In one classic YouTube video, a woman is caught on camera composing a text message on her cell phone while walking through a mall—until she tumbles headfirst into a water fountain. The stakes can be much higher when driving while maintaining a cell-phone conversation.

Tuning attention properly is key to healthy cognition. Several mental disorders stem from the failure to amplify or suppress details of the environment.

Bolstering the theory of a limited attention span, scientists have observed that cell-phone drivers' reactions are slower, they have difficulty staying in their lane and maintaining appropriate following distance, and they are more likely to run red lights and miss other important details in the driving environment. We recently conducted an observational study of 56,000 drivers as they approached an intersection where they were required to come to a complete stop. We found that drivers talking on their cell phone were more than twice as likely to fail to stop appropriately.

At any given time during the day, about one in 10 individuals are both on the road and on the phone. Intersection violations are potentially hazardous events, so it is alarming to see that such a common behavior is associated with this level of impairment. In fact, we have reviewed a number of legal cases where a driver talking on a cell phone failed to notice a red traffic light and proceeded through the intersection, causing an accident that resulted in serious injuries or fatalities. Understanding when we can and cannot multitask is not just an academic exercise—it is a matter of life and death.

Driven to Distraction

To study distracted driving in finer detail, we monitored participants using a realistic driving simulator. Using this device for a study in 2006, we found that the crash risk for those using a cell phone to talk or text often exceeds the level observed with drivers who are at the legal limit of alcohol intoxication.

Also using a driving simulator, we observed individuals' eye movements and the corresponding brain activity through electrodes attached to the scalp. We found that drivers failed to notice up to half of the items that they looked at, and we confirmed that they reacted substantially more slowly to the information that they did detect.

In research published in 2003 and 2007, we tracked participants' gaze to note what items they looked at and then quizzed subjects later about what they recalled observing. Their memory for the items their eyes fell on was only half as good while they were talking on a cell phone as when they were not distracted by the phone. A follow-up study published in 2007 found that this pattern was observed with both highly relevant items, such as a child standing on a sidewalk, and with less important landmarks, such as a billboard alongside the road. In other words, the brain does not prioritize information by its importance when deciding what is "lost" while the driver is on the phone. Lapses of attention essentially rendered the drivers partially blind to significant details directly in their gaze.

The simulator used by the authors re-creates a realistic driving experience. Subjects wore caps dotted with electrodes to measure their brain activity under various conditions, including while talking on the phone.

To establish that cell phones induce a form of inattention blindness, we again used electrodes on the scalp to compare the brain signals associated with the detection of illuminated brake lights on the vehicle in front of the driver. We measured the drivers' brain activity both when they were talking on a hands-free cell phone and when they were not distracted by such use.

A particularly interesting component of these

(The Authors)

DAVID L. STRAYER and JASON M. WATSON are both psychologists at the University of Utah.

ISTOCKPHOTO (*top*); COURTESY OF DAVID L. STRAYER (*bottom*)

Manage Your Multitasking

By Lena Groeger

Writer and humorist A. J. Jacobs strapped himself to his chair with an extension cord to stay focused on his computer. David Teater, an employee at the National Safety Council, locked his cell phone in the trunk of his car to avoid checking it whenever it rang. People have gone to extreme lengths in the pursuit of focus because distractions—and thus multitasking—are so hard to resist. But you need not resort to such drastic measures just to get things done.

First, some training can help. Certain simple and repetitive actions, such as typing, can become almost automatic and free up some of our attention. Professional musicians and athletes, for example, have mastered behaviors that would challenge beginners. As a result, the experts can focus on nuances, such as adjusting their style for a new concert venue or strategizing how to get a hitter out.

Yet as Vanderbilt University neuroscientist René Marois notes, practice cannot prepare you for a novel or unexpected event. Nor does training transfer to other skills. Getting better at composing a letter while pedaling an exercise bicycle will not help you craft clever Twitter updates while also paying attention in class. "You might be an excellent multitasker for a particular set of tasks, but that doesn't mean you're a better multitasker at anything else," says psychologist Ulrich Mayr of the University of Oregon.

He and other researchers recommend learning instead to focus on one thing at a time. Clifford I. Nass, a professor of communication at Stanford University, suggests tackling e-mail, a prime distraction: try setting aside 20 minutes a few times a day to answer e-mails and then shutting it off. He also urges people to look out for subtle interferences that can disturb concentration, such as background music with lyrics or noise from a television.

Even under the best conditions, however, most people cannot focus intensely for more than 20 to 30 minutes. Psychologist Priti Shah of the University of Michigan at Ann Arbor recommends taking breaks, perhaps by going for a walk outside or switching to a less demanding task. Doing so can shake loose new ideas and approaches when you resume the challenge later.

Checklists can also help manage the daily influx of new duties. To beat multitasking in her own life, Shah rewards herself for completing an activity, often with a cup of coffee or a snack. Seeing items listed one after another can make them more concrete, she adds, and the satisfaction of crossing them off can motivate you to stay on track.

Reconfiguring your workspace can limit distractions, too. While engaged in writing, psychologist Paul Dux of the University of Queensland in Australia tries to keep only one document open on his computer at a time and avoids consulting the Internet. Shutting off the wireless connection for a few hours a day can also minimize temptations. (Free software programs can lock you out of the Internet for a specified amount of time.)

Finally, beating multitasking may come down to one word: no. Turning down engagements that will splinter your attention can ultimately let you accomplish more. With all the time you saved by not multitasking, you may get to say yes to more of the things you really want.

Lena Groeger is a science writer based in New York City.

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brain waves, known as the P300, is a signal that is sensitive to how much attention a person is paying to a specific stimulus. The amplitude of the P300 signal increases as more attention is allocated to a task. When drivers were talking on their cell phone, we found that the amplitude of the P300 was cut in half—a drop that reflects their decreased focus on the task of driving. The reduction in the P300 explains why drivers often fail to detect and react to events in the driving environment. Their brain is busy processing the conversation and not what they are looking at through the windshield.

Because both handheld and hands-free cell phones cause equivalent interference, it establishes that this is a form of *cognitive* distraction, as opposed to, say, a visual distraction that draws the driver's eyes from the road or a manual distraction that compels the driver to remove his or her hands from the wheel. Even with eyes on the road and both hands on the wheel, the individual is impaired.

This finding has implications for a recent trend in state legislation. Many states have implemented laws prohibiting the use of handheld phones but permitting hands-free cell phones. Statistics from the Highway Loss Data Institute, a nonprofit road safety research group, indicate that such legislation has not improved traffic safety. More important, our studies suggest that the level of cognitive distraction is equivalent for both kinds of cell-phone use. These results also imply that computer-based speech-rec-

ognition systems currently being installed in vehicles are not likely to eliminate the problem.

Even so, not all distractions are created equal. When comparing the effects of being on the phone with chatting with another passenger in the car, for example, we found that the passenger and driver adjusted their conversation based on driving demands. The passenger also assisted by noting hazards and reminding the driver of their navigation goal. This real-time adjustment in the dialogue to road conditions was not observed with cell-phone conversations. In fact, drivers chatting with a passenger had no trouble getting to their destination—in the case of our experiment, a roadside rest stop—whereas half of the drivers on a cell phone completely missed their exit.

Frequent multitaskers tend to be more impulsive and sensation-seeking, as well as overly confident in their ability to juggle mental activities.

Practice Makes Imperfect

Perhaps, you might argue, these individuals were simply not accustomed to the rigors of driving while on the phone. In this case at least, practice does not seem to lead to great gains in performance. When we compared drivers who frequently used cell phones with those who did so less often, we did not find that the first group was less impaired, and extensive laboratory practice also did not appear to help.

The reality might actually be even more dire, however, than a straightforward lack of improvement. In 2009 Clifford Nass of Stanford University and his colleagues assessed individuals on the degree to which they engaged in multitasking and timed how long it took them to switch among tasks, specifically between classifying a digit as odd or even and judging whether a letter is a consonant or a vowel. They found a negative correlation between the two measures, whereas higher self-reported levels of media multitasking were associated with longer times for people to switch between classifying digits and letters. It appears that trying to do several things at once actually diminishes your skills.

In a recent collaboration with social psychologist David Sanbomnatsu, our colleague at the University of Utah, we asked more than 300 participants to rate the frequency of their multitasking and their perceived ability to do so (relative to the average college student) and then asked them to complete a multitasking test. In the exam, participants memorized an ordered list of items and tried to keep them in mind while simultaneously solving math problems. Using standard questionnaires, we also rated how impulsive and sensation-seeking the participants were.

Our data all showed the same pattern: people who were high in real-world multitasking had lower working-memory capacity, were more impulsive and sensation-seeking, and tended to rate their own ability to multitask as higher than average. That is, their perceived ability and actual ability to multitask were inversely related. This work suggests that overconfidence, rather than skill, drives the proliferation of multitasking.

Whether doing several things at once depletes working memory or whether those who formed a habit of multitasking already were less adept at mentally manipulating various pieces of information concurrently is not yet known, although we suspect that both might be true. We have some early evidence that multitasking causes a kind of cognitive depletion and that "unplugging" has restorative properties.

As for what might feed the underlying motivation to multitask, one possibility, as suggested by lab studies done in 2007 by Stephen J. Payne of the University of Bath in England and his colleagues, is that individuals switching among tasks are seeking to increase the time spent on the activity that produces the most reward. That observation could well match our reports that heavy multitaskers tend to be sensation-seeking. Whatever the cause, a divided attention appears to impede performance rather than assisting it.

The inability to overcome these costs is particularly salient when it comes to reacting to an unexpected event, such as a child running out into the street. But as we were about to learn, not everybody fits that mold.

Search for Supertaskers

We found our first exception to the rule completely by accident. We were comparing our study participants' scores on different tasks, such as driving alone, talking on a hands-free phone alone, and doing both concurrently. After going through the data, however, we identified one unusual subject

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Supertaskers are able to juggle multiple mental activities effortlessly. A supertasking chef, for example, might be particularly adept at simultaneously preparing numerous dishes to perfection.

ADRIAN WEINBRECHT *Getty Images (top)*; ISTOCKPHOTO *(bottom)*

who had virtually identical scores for doing either just one or both activities. After checking and rechecking the data, we realized that this person was multitasking in ways we had not thought possible. We continued our data collection in search of more such anomalies. After testing approximately 700 people, we have identified 19 people so far who meet the "supertasker" criteria, or about 2.5 percent. These individuals all ranked among the top 25 percent when doing a single task, and their performance did not deteriorate when completing two assignments at once.

To identify the neural regions that support supertaskers' extraordinary multitasking ability, we used functional MRI. We scanned 16 of our supertaskers as well as a group of subjects who matched them in their single-task scores, working-memory capacity, gender and age, among other measures. Because the driving simulator and the MRI facilities are incompatible technologies, we switched to a computerized multitasking test that required participants to concurrently maintain and manipulate separate visual and auditory streams of information.

> The emergence of our multitasking ability, however flawed, might be a relatively recent evolutionary change, helping to distinguish humans from other animals.

We saw significant differences in the patterns of neural activation of supertaskers and the control group. Supertaskers showed *less* activity at the more difficult levels of the multitasking test. For most people, a tougher challenge recruits more resources in the brain, but supertaskers showed little or no change in brain activity as the task became more demanding, suggesting that somehow these individuals can achieve greater efficiencies and, along with it, higher performance. Our supertaskers seem to have the "right stuff," keeping their brains cool under a heavy load, just as fighter pilots are reported to do in demanding situations. Because our studies controlled for working-memory capacity, we know that working memory is important but not sufficient to account for superior multitasking abilities.

Supertaskers differed most strikingly from control subjects in three frontal brain areas that earlier neuropsychological research on multitasking had flagged: the frontopolar prefrontal cortex, dorsolateral prefrontal cortex and the anterior cingulate cortex. For us, the most intriguing brain region that differentiated supertaskers from controls was the frontopolar cortex. Comparative studies with humans and great apes indicate that this area is relatively

larger and more richly interconnected in humans, whereas other frontal cortical areas are more equivalent in size and connectivity. The emergence of humans' multitasking ability, however flawed, might be a relatively recent evolutionary change in hominid brains, helping to distinguish humans from other animals. In addition, neuropsychological patients with more extensive frontopolar damage have been shown to be more impaired in multitasking. Now we know that high levels of efficient processing in these regions support extraordinary multitasking ability, bringing us one step closer to finally developing a model of how the brain multitasks.

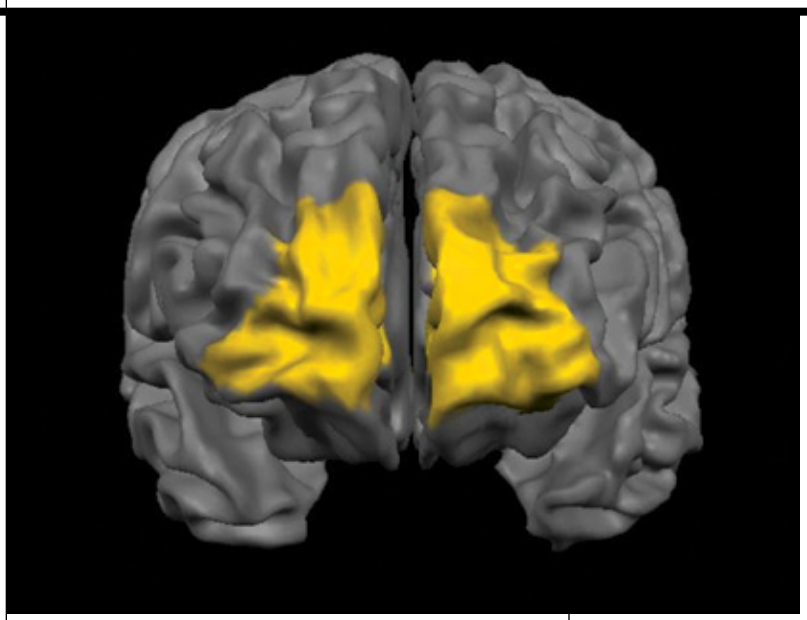
The examination of individual differences in multitasking ability is a relatively new enterprise, however. Whether supertaskers are just an extreme on a continuum or are qualitatively different is still an open question.

The Multitasking Advantage

To tease out what distinguishes these brains, we are now looking for differences in the connections among regions in the supertasking brain as well as hunting for unique features in their genetics, either of which could lead to more efficient processing for these individuals. Variants of one particular gene, *catechol-O-methyltransferase* (*COMT*), for example, are associated with differences in working memory, executive attention and a slight predisposition to a broad number of psychological disorders.

One reason to examine this gene is that its variants alter how efficiently the neurotransmitter dopamine can operate in the frontal cortex, which encompasses the brain regions that support multitasking. It is thought that lower *COMT* enzyme activity may result in greater availability of dopamine for binding at receptor sites in the frontal cortex. By sequencing the DNA in samples of our supertaskers' blood or saliva, we have found preliminary evidence suggesting that these individuals possess a variant of *COMT* that leads to more efficient dopamine signaling in the regions of the brain supporting multitasking. We are still investigating whether the features of this gene might explain supertaskers' superior powers of attention.

To expand our research, we will need to find more supertaskers. It is intriguing to consider where we might find them—that is, which occupations might ideally suit supertaskers. Pilots of high-performance aircraft are good candidates to be supertaskers. So, too, are high-end chefs who can cook several meals at the same time to perfection. Perhaps some of the star quarterbacks in the National Football League are supertaskers. Champion video gamers may also be a good bet, as are the elite doctors in hospital emergency rooms. All other things being equal, we suspect that supertaskers will rise to the top in any occupation that places a high demand on juggling various attention-demanding tasks at the same time.



The frontopolar regions of the brain (*yellow*) may be recruited during multitasking.

Exploring why the supertasking mind excels where the rest of us fail might help us structure tasks so they do not overtax the brain's abilities, such as using auditory cues in contexts where visual information is overwhelming. The research can also add more nuance to our understanding of attention-related psychiatric problems, including obsessive-compulsive disorder, thought disorders and attention-deficit hyperactivity disorder.

Given the rise of technology over the past few generations and the role it has played in making frequent multitasking possible, one might ponder the potential long-term consequences of a society that places such high value on this skill. Returning to Einstein's observations on driving and kissing—or talking on a cell phone—the vast majority of us cannot multitask without significant costs. In the very distant future, supertaskers' ability to better cope with multiple goals and information sources may be an increasingly adaptive feature in the evolution of our species. M

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COURTESY OF DAVID L. STRAYER AND JASON M. WATSON, GENERATED WITH BRAINVOYAGER BRAIN TUTOR SOFTWARE (*brainvoyager.com*)

A MIND IN DANGER

Signs of incipient psychosis show up early in life. Reading them is key to rescuing kids from the abyss of a serious mental illness

By Victoria Costello

From the moment he was handed to me in the delivery room, Alex, my firstborn, seemed not happy to be here. His eyes were bottomless, his expression grave. He spent his first three months writing and screaming inconsolably, the word "colic" wholly insufficient to describe our collective suffering. It wasn't until his brother, Sammy, arrived that I realized just how different Alex was compared with other babies. Sammy cried only when he was hungry or wet. He made easy eye contact and loved to be stroked, hugged and kissed—all the things Alex recoiled from as an infant.

Later, when I took Alex to playgroups, he crawled away from the other toddlers to do his own thing, so we quit going. It wasn't that Alex appeared unhappy. He would sometimes sit and smile with satisfaction for no apparent reason. At age two and three, Alex attended a Montessori preschool. Although he

JIM POWELL *Aurora Photos*

RUTH JENKINSON Getty Images

Mothers often describe children who go on to develop schizophrenia as being in a world of their own. These kids tend to opt out of a social scene rather than joining the fun.

enjoyed the hands-on activities, his teachers often commented that he usually ignored them as well as the other children. His first grade teacher thought he must be hard of hearing because he routinely ignored her directions, especially the daily reading and writing drills she assigned. In one of the first studies ever done with families afflicted with schizophrenia, the Edinburgh High Risk Study, Scottish mothers commonly described children who went on to develop the disorder as occupying a world of their own.

I had so often thought of Alex the same way.

Alex first began to manifest the so-called negative symptoms of schizophrenia in puberty. These included a loss of motivation, social and emotional withdrawal, a disinterest in hygiene and dress, and trouble sleeping. The term "positive symptoms" refers to the more obvious behaviors we think of as "crazy"—hearing or seeing someone who is not there, for example, or holding fixed, illogical beliefs—and they would unfortunately come, too, a little later, as they are known to, right before the first psychotic break.

Knowledge of schizophrenia as a long-term disease process has existed since the early 20th century. The initial signs of this process—the impaired body sensations, reduced tolerance to stress, increased emotional reactivity and, especially, social deficits—"can appear more or less continuously between two months and 35 years prior to their progression to the first psychiatric symptoms," wrote German researcher Joachim Klosterkötter of the University of Cologne in a 2001 essay.

Although much of the profession still focuses on the debilitating full-blown illness, paying attention to its origins and early stages provides the greatest chance of altering its course. In particular, adjusting a child's environment is one important way of minimizing the impact of this serious mental illness. Parenting does not cause schizophrenia, at least not on its own, but that does not mean that parents and other adults are powerless to protect children from it.

Weighing the Chances

In an 1896 treatise German physician Emil Kraepelin observed that many of the children of his schizophrenic patients, especially those who would go on to develop the disease themselves, were "a little different in character and behavior from their peers—beginning in early childhood." The accumulating evidence now backs up Kraepelin's observation that a significant number of individuals later diagnosed with schizophrenia display some common and often peculiar traits and experiences as children or adolescents.

Knowing risk factors and warning signs can save many children from being diagnosed too late for the most effective treatment. With autism, for example, the American Academy of Pediatrics has issued guidelines for parents and physicians as a result of lobbying efforts by autism advocacy organizations. Parents are to watch for possible behavioral signs such as a baby avoiding eye contact, being slow to babble or experiencing sudden developmental regressions, and screening is recommended for infants as young as nine months. Parents and doctors can

FAST FACTS

Stop the Madness

1» **Signs of a mind in danger—including social deficits, impaired body sensations and reduced tolerance to stress—may show up anywhere from two months to 35 years before schizophrenia strikes.**

2» **The prevalence of schizophrenia is 1.1 percent, but if a parent has the disorder, the child has a 10 to 12 percent increased risk and a 17.1 percent chance of developing a related personality disorder.**

3» **Physical abuse, bullying by peers and ingesting cannabis can push a genetically vulnerable child toward psychosis.**

begin to think similarly about other childhood mental disorders, including schizophrenia.

The prevalence of schizophrenia in the general population is 1.1 percent, but if a parent has schizophrenia, the child has a 10 to 12 percent risk of developing it. She also has a 17.1 percent chance of developing a personality disorder in the same "spectrum" as schizophrenia, such as paranoid or schizoid personality disorder, compared with the background rate of 3 percent for these afflictions in youths, according to the U.S. Surgeon General. Her chances of an anxiety disorder are similarly raised—to 16 percent, from an average rate of 13 percent for children. The odds of having a conduct disorder also go up from 10 to 13 percent if a parent has schizophrenia. This same inherited liability can alternatively manifest as a learning disorder. Recent studies with "unaffected" children of a schizophrenic parent—meaning they are free of the disease's symptoms—have established their higher risk for a retinal eye defect that can interfere with visual learning.

In addition, a well parent can pass on a risk for the disease without noticeably manifesting its symptoms. A carrier may have symptoms that are below the clinical threshold for a disorder. For example, a mother may display what psychologists call an idiosyncratic use of language, which is a low-level version of the "thought disorder" symptom that can occur in her adult child with psychosis. I discovered such a high-low symptom linkage between Alex and me. It arose when I would go "blank" midsentence, being briefly embarrassed by the words coming out of my mouth and scrambling to compensate with another clarifying sentence.

IN OLD MOVIES EXPERTS PICKED OUT THE PRESCHIZOPHRENIC KIDS BY THEIR FLATTER EMOTIONS AND LESS COORDINATED MOVEMENTS.

I trust you're getting the picture that everything about your family's medical and mental health history—including a relative's weird habits, addictions and "moodiness," any diagnosed medical or neurological condition, and unexplained accidents—can be relevant to your or your child's mental health care today. Because so many of us don't know our family mental health histories, we're often thrust into the role of sleuths, connecting the dots among pieces of evidence to identify a vulnerability that may be lying in wait.

Very Early Signs

In one extraordinary family study from 1990, researchers at Emory University collected early home movies from families with a schizophrenic adult. The scientists easily identified the preschizophrenic kids from their siblings because of their flatter emotional states—they showed less joy or distress—and fewer coordinated movements. As the investigators suspected, the films depicted signs of schizophrenia de-

A child's mental health hinges hugely on the psychological well-being of his immediate family and relatives. The risk of schizophrenia can depend on a variety of ailments present in the family tree, some of which may remain undiagnosed.

ISTOCKPHOTO

HANS WOLF *Getty Images*

One risk factor for schizophrenia is living in an urban setting. No one knows why. Do certain aspects of city living—exposure to violence or viruses, say—contribute to mental illness, or are cities somehow more attractive to vulnerable people?

cades before these children went on to develop it.

Recent studies have documented early psychotic symptoms in children as young as 12 and even five years of age. You may wonder, as I did, "Don't all five-year-olds play pretend and have imaginary friends?" The answer is yes, they do. But, researchers say, trained mental health workers using reliable diagnostic interview tools can tell the difference between ordinary childhood fantasies and deeper signs of psychological trouble. None of the children participating in these studies were identified at the beginning as mentally disturbed, making the documentation of their lives and vulnerabilities a process of discovery for these researchers.

In one such study, the British Environmental Risk (E-Risk) Longitudinal Twin Study, 1,116 mothers with five-year-old twins participated in home-visit assessments. The 2,127 children in the group were evaluated first at age five and then followed to age 12 with 96 percent retention. In addition to the children's mental health, interviewers assessed a wide range of factors in the child's family, school and home that might contribute to a higher risk for psychosis.

Interviewers explored garden-variety symptoms of psychosis with questions such as "Do you ever hear or see things that other people can't hear or see?" As it turns out, the vast majority of normal five-year-olds answer these queries as almost all normal 16- and 30-year-olds from a general population would, with a simple "no." In the E-Risk study, 7.9 percent answered "yes," putting them in the category of having a "probable" symptom of psychosis. Yet when researchers probed deeper, they determined that only 4.2 percent had a "definite" symptom of an auditory hallucination. To find out whether any of these children may have experienced a delusion, workers asked, "Have you ever thought you were being followed or spied on?" Here 2.5 percent had the probable symptom, but in the end only 15 children, or 0.7 percent, definitely displayed delusionary thinking.

Once signs of psychosis were confirmed in

(The Author)

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125 children, researchers looked for common risk factors present in their lives. The most telling commonality was that all the 12-year-old children with current psychotic symptoms had had significantly more emotional, behavioral and educational problems at age five than did their asymptomatic peers. The most predictive problems, which tended to worsen with time, were antisociality and hyperactivity, but others were childhood depression and anxiety. The researchers acknowledged that these behaviors were not specific to schizophrenia and can occur in the context of other disorders, including ADHD, antisocial conduct, depression and anxiety.

One particular cause for alarm: these children with early psychotic symptoms were also more likely to have engaged in self-harm, which, according to their mothers, included cutting themselves with razors and beating their heads against the wall; one child even attempted a hanging. "Given the fact that children can conceal self-harm from parents, the association between psychotic symptoms and self-harm may be underestimated here," the researchers wrote.

Although the vast majority of kids grow out of their early childhood emotional and behavioral challenges, an important minority do not get better on their own, researchers say. The children at highest risk are those living with others afflicted with serious mental health problems. In the E-Risk study, about twice as many of the affected 12-year-olds' relatives had been admitted to psychiatric units, and 29 of these relatives had made suicide attempts.

Results from the longer-term, ongoing Dunedin Multidisciplinary Health and Development Study in New Zealand indicate that symptoms of psychosis at age 12 do, in fact, augur psychological problems later on. In this study, researchers assessed individuals born between April 1972 and March 1973 in Dunedin, starting at age three and again every two years thereafter. Psychiatric evaluations of 789 children revealed symptoms of early psychosis in 116, nearly 15 percent, who were not initially thought to be at high risk. The presence of such symptoms, the researchers found, was strongly predictive of personality disorders in young adulthood. Specifically, 42 percent of those who later developed either schizophrenia or a related personality disorder had reported experiencing a psychotic symptom, such as a hallucination, when they were interviewed at age 11. [For more on predicting psychosis, see "At Risk for Psychosis?" by Carrie Arnold; Scientific American Mind, September/October 2011.]

14 IS THE AGE BY WHICH HALF OF ALL ADULT MENTAL DISORDERS BEGIN, INCLUDING ANXIETY, DEPRESSION AND SCHIZOPHRENIA.

Bullying can do serious damage to a young person's brain. More than just hurting the victim's feelings, the behavior can tip a susceptible child toward psychosis.

GETTY IMAGES

Although subtle signs in Alex manifested slowly in the course of his childhood, after he reached his 14th year, to say that all hell broke loose would be an understatement. I was, therefore, not surprised to later read national epidemiological data identifying 14 as the year by which half of all adult mental disorders begin, including anxiety disorders, bipolar disorder, depression, eating disorders, conduct and oppositional disorders, psychosis and schizophrenia. Scientists looking into this phenomenon attribute it to the tremendous growth spurt that begins in puberty when an adolescent's brain, body and emotions are transformed as never before or ever again. This is also the age when the mental illnesses affecting boys and girls sharply diverge, with girls becoming suddenly more vulnerable to depression, whereas boys begin to populate clinics specializing in early psychosis.

Stemming Psychosis

Although most pubescent children sail through this normal maturational process, those at risk of becoming derailed by it need help. Negative risk factors for schizophrenia come in different forms [*see box on next page*]. Many scientists believe that aspects of a person's environment can activate the gene or genes that confer greater vulnerability to a disease such as schizophrenia. The bottom line is that a vulnerable young person can take only so many additional environmental insults before he reaches the point of no return.

How do we as individuals and parents work with known risk factors to prevent mental illness? We start where the scientific evidence is strongest. It is clear that a baby's prenatal experience and the quality of parental care received during the first five years of life top the list of significant environmental risk factors. When a family has a history of mental illness, the research tells us that a high level of stress for a mother during the first trimester of pregnancy can raise a child's risk for schizophrenia—as can obstetrical complications and a baby's low birth weight.

There is now no doubt that physical abuse, bullying by peers and ingesting cannabis can do great damage to a genetically vulnerable prepubescent child. We understand that conduct problems in early childhood and adolescence can lead to antisocial adults and raise the risk for psychosis. Further, we know that *where* we live and the quality of schools can also change the odds. One big negative, for instance, is living in an urban environment. In the E-Risk study, for example, 65 percent of the affected children were city dwellers. Epidemiologists are not sure why: Are city residents more likely to develop serious mental illness because of urban social isolation, exposure to pathogens, stress or violence? Or do psychologically vulnerable people tend to migrate to cities?

Finally, we are very aware that the level of chaos in a household and the presence of untreated adult psychiatric problems can also negatively affect any child's mental health—but particularly that of one carrying a higher genetic risk. On the other hand, growing up in a stable home with loving, supportive parents is the most powerful "neuroprotector" a child can have on her side.

WE'VE GONE TOO FAR IN THE DIRECTION OF BLAMING BIOCHEMISTRY AND OF NOT TAKING RESPONSIBILITY FOR SHAPING OUR CHILDREN'S BRAINS.

If it sounds like I'm getting dangerously close to the historical tendency to blame parents for the psychological ills of a child, to a certain degree I am. I believe we've gone too far in the direction of blaming biochemistry and not taking responsibility for our own roles in shaping the health of our children's brains. I'm advocating transparency and the taking of greater responsibility by everyone—parents, extended family members, mental health practitioners and our larger communities, including corporate health care and government-

CHILDHOOD RISK FACTORS FOR SCHIZOPHRENIA

Smoking cannabis and experiencing maltreatment between the ages of three and eight have a significant "dose response" correlation with psychosis; that is, the more smoking or maltreatment, the greater a child's risk. All the other factors below bump a vulnerable child's risk only slightly. If, as a parent, this list sparks concern, you may choose to monitor your child more closely or, if the symptoms are plentiful and worrisome enough, to take him or her for an evaluation.

1. A family history of schizophrenia or another psychotic disorder, suicide, or repeated hospitalizations for psychiatric disorders.

2. Prenatal and parenting risk factors:
- _ Older father. [See "The Father Factor: How Dad's Age Increases Baby's Risk of Mental Illness," by Paul Raeburn; SCIENTIFIC AMERICAN MIND, February/March 2009.]
- _ Maternal emotional stress during the first trimester; especially the loss of a spouse.
- _ Obstetrical complications; any loss of oxygen.
- _ Winter birth.
- _ Maternal malnutrition or famine.
- _ Disease agents: influenza, rubella, especially during the middle trimester.
- _ Chaotic household.
- _ Maternal depression.
- _ Physical maltreatment.

3. Social and economic risk factors:
- _ Being a migrant or the offspring of migrants.
- _ Living in an urban environment.
- _ Lower socioeconomic status.
- _ Bullying by peers.

4. Behavioral risk factors in a younger child*:
- _ Sitting, walking and talking later.
- _ Lack of physical coordination in later childhood.
- _ Fewer expressions of joy and a flatter affect (emotional expression).
- _ A preference for solitary play at age four.

5. Behavioral risk factors—older child or adolescent:
- _ Lack of physical coordination; being viewed as clumsy at age 16.
- _ Having two or fewer friends at age 17.
- _ Lower IQ, especially immediately before onset, and learning problems in school.
- _ Social anxiety and withdrawal (a higher IQ and a sociable temperament are mitigating factors that can diminish other risks).
- _ Depression.
- _ Difficulties with working memory.
- _ Antisocial behavior and conduct disorders; problems with peers, teachers, authorities.
- _ Acts of self-harm; suicidal ideation.
- _ Early tobacco smoking.
- _ Cannabis use, especially three or more times per week and before age 15.

*Most late-walking and late-talking toddlers and withdrawn or antisocial kids *do not* go on to develop mental disorders.

SOURCE: This summary reflects a large body of studies in which children were tracked over time, as well as others that were retrospective, meaning parents and the individuals themselves were asked to look back on the past.

administered services—for the mental health of our children and future leaders. For grandparents, that may mean giving up an old family secret over which you still carry considerable shame. For parents, it means first becoming more educated about what factors contribute and detract from a child's positive emotional growth.

In a 2009 report entitled *Preventing Mental, Emotional, and Behavioral Disorders among Young People: Progress and Possibilities,* the Institute of Medicine and the National Research Council assembled voluminous evidence to show that mental illness is preventable in children. Programs that teach parents effective parent-child emotional communication skills are among the most useful that have been tried. There were also robust positive results from interventions aimed at reducing substance abuse, conduct disorder, antisocial behavior, aggression and child abuse, as well as programs that help children struggling with depression after a divorce and efforts to reduce aggressive conduct in schools.

The issue of drug use is a particularly important one for parents to grapple with. According to the University of Michigan's annual Monitoring the Future survey, marijuana use by American adolescents—especially eighth- and 10th-graders—was up in 2009 for the third year in a row, reversing a decline tracked since 1992. The age of first-time marijuana users is also dropping, and fewer teenagers believe there is a serious health risk associated with marijuana use. When Alex first started smoking pot, I did not view it as his biggest problem behavior. Far bigger, I thought, was the fact that he had not done his homework in recent memory. Yet as psychiatry professor Demian Rose of the University of California, San Francisco, told me, "the data are quite clear that heavy marijuana use increases the risk of developing chronic psychosis fivefold to 10-fold—even after young people stop using."

A final note on school violence: in one study of 6,437 British 12-year-olds, researchers found that a child's risk of psychotic symptoms was increased twofold if he had been bullied between the ages of eight and 10. If he had been more severely and more often victimized by his peers, the child's risk of psychosis doubled or tripled.

In the past, our culture has quietly condoned bullying as a rite of passage by looking the other way. After a couple of decades filled with school shootings and other gruesome crimes committed by young people against their peers, this stand is no longer popular. Still, bullying continues. It has moved online and has become more prevalent among girls. If your child is being regularly teased, pushed, tripped, verbally harassed or ostracized at school or in the neighborhood or if he is being persecuted online through the misuse of social-networking Web sites, you must be your child's first line of defense. Don't wait. Act. The same goes if you witness another child being victimized in any of these ways.

Growing up in a stable home with loving, supportive parents offers a child strong protection against mental illness.

Treating a child for the first signs of mental distress is the essence of early intervention and secondary prevention—the type used to stop an illness from getting worse. This treatment does not necessarily mean introducing a psychiatric medication. The earlier the symptoms are noticed, the less invasive or onerous the treatment tends to be. If medication is what it takes to stop the advance of a disease process in a child, however, any concerned parent should give it serious consideration and weigh the risks and benefits carefully. Most adult mental disorders begin in childhood or adolescence. Those that are treated before adulthood have the best outcomes—meaning a remission of symptoms. This is what we're after. M

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CORBIS

THE SECRETS OF SELF-IMPROVEMENT

Meet your goals with research-proven tips and techniques

BY MARINA KRAKOVSKY

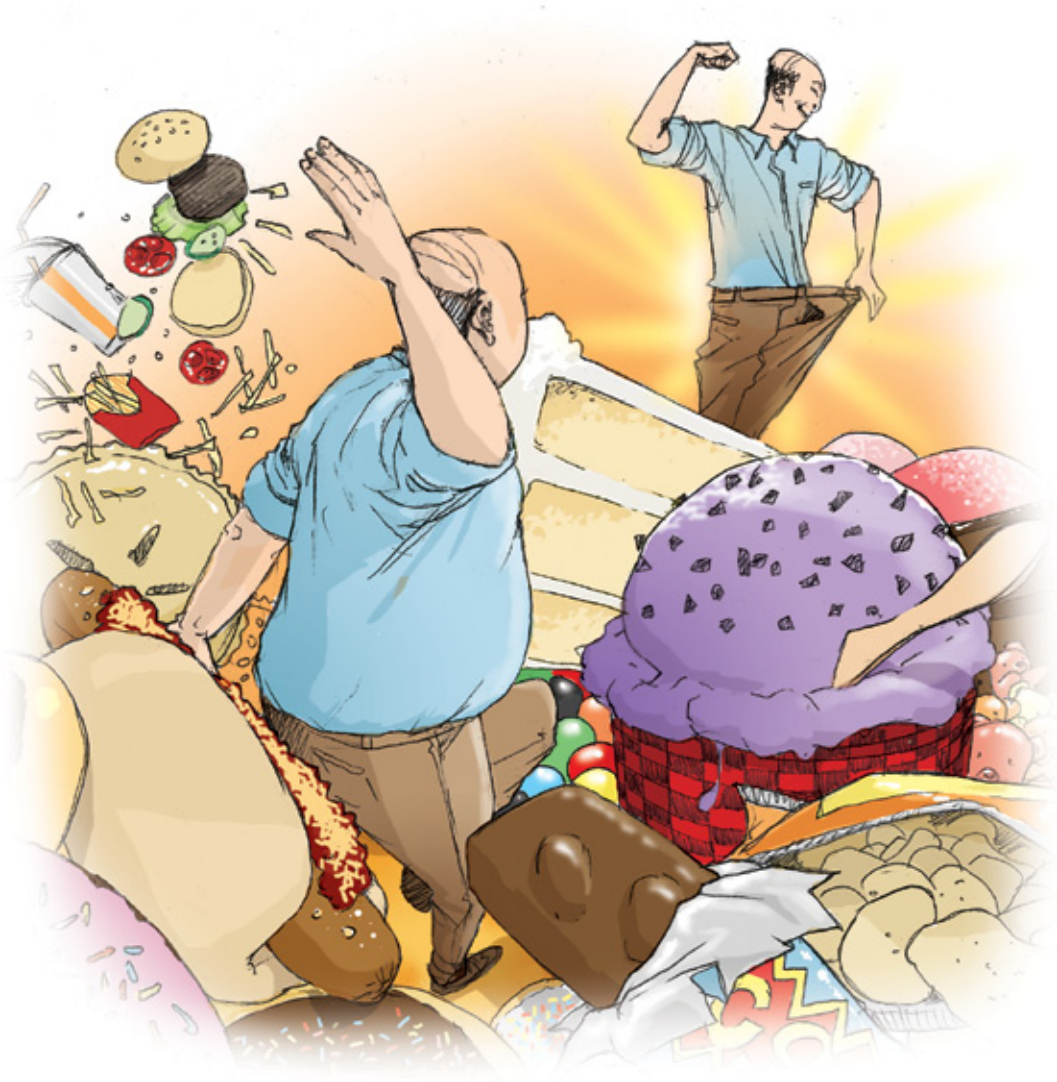
Have you already abandoned your New Year's resolution? No need to feel ashamed. Fully a quarter of the people who make resolutions give up by the end of the first *week,* with many others falling off the wagon in the months to come. It seems to be human nature to aim high and fall short.

Whether attempting to exercise more regularly, cut back on impulse buying or simply keep a tidy desk, anybody who has tried changing a long-standing habit knows how frustratingly hard lasting change can be. But why is it so difficult, despite our good intentions? What do those few who succeed know that the rest of us do not?

These questions are as intriguing to scientists as they are to those of us aiming toward our own goals, and decades of research have given us a good idea of the answers. Lifestyle changes require adjustments to mind-set, motivation and intent. Dreaming big is fun, but setting realistic expectations will prepare you better for the challenges to come, as will putting specific plans in place for when you face them. Start small with short-term, achievable goals to build up your confidence as you move forward. Find a deep, personal motivation that can keep you feeling accomplished and in control of your fate. Create new routines that will make your desired behaviors as automatic as the bad habits you wish to break.

The best news is that by using these techniques, even drastic personal revolutions are eminently achievable, without the help of doctors or programs. "Most of the time people *do* make positive changes on their own, which is important for everybody to remember," says Richard M. Ryan, a psychologist at the University of Rochester. Here's how you can do it, too.

ILLUSTRATIONS BY MATT VINCENT



Making specific plans about what you will do when faced with tough choices will help you say no to temptation and keep fighting toward your goal.

Old Problems, New Approaches

Scientists have long been tackling the problem of how to get people to do what is good for them. Until the past 10 to 15 years, however, most ideas have not stood up to real-world testing, says Martin Hagger, a health psychologist at Curtin University in Perth, Australia. For instance, scholars thought that individuals would not smoke if they understood that doing so is bad for them. Yet no amount of information about smoking's deadly effects proved to have much of an impact on quitting rates. It turns out that we have a much harder time changing our actions to align with our thoughts than the other way around. It is far easier, in other words, to make excuses for why we are still smoking—or eating junk food or not flossing our teeth.

Today's researchers are looking beyond older notions of willpower, finding that successful reform requires much more than the ability to control your impulses. A crucial first step is to know going in that mending your ways will not be easy. Understanding why will help smooth the bumps on the road ahead. "What makes habits hard to change is what makes them so useful," says Wendy Wood, a psychologist at the University of Southern California who studies habit breaking. Habits make life easy, so we do not have to think about things such as putting on our shoes before leaving the house. Simply being in a particular place prompts the action—a fact that,

FAST FACTS

Lasting Change

1» **Psychologists have recently uncovered several techniques to help people meet their goals.**

2» **Long-term lifestyle changes require a combination of realistic expectations, internal motivation and achievable action plans.**

3» **People can learn these strategies and implement them on their own, without help from therapists or special programs.**

unfortunately, is equally true for those peccadilloes we wish to eliminate.

A stark demonstration of this reality is a recent experiment by Wood and her colleagues, published last year in the *Personality and Social Psychology Bulletin*, in which they gave either fresh or week-old popcorn to subjects who habitually ate popcorn at the movies. They ran the test in several environments. Nobody particularly liked the stale popcorn, but they nonetheless ate just as much of it as the fresh stuff. The good news was that this pattern held only when they were watching movie trailers in a theater but not while watching music videos in a conference room, where the change in cues blunted the mindless impulse to eat. Planning ahead to minimize such situational hints is one way to break habits—if you are trying to give up caffeine, for instance, find a route to work that does not take you past Starbucks.

Forming a new habit, so as to get in shape or read more classics, for example, usually requires choosing between the pleasant or familiar and something much less so. Most people overestimate the ease of this willpower challenge, which gets them into trouble. In a set of experiments published in *Psychological Science* in 2009, participants with the highest opinions of their self-restraint were the most likely to give in to temptation, whether it was in the form of cigarettes or fatty snacks. Those with the most modest, realistic assessment of their abilities, on the other hand, fared best.

Lasting change, of course, requires making the right choice time and time again for the rest of your life—in all kinds of difficult situations. "If you simply think, 'I can do it. I simply have to refrain,' then you're likely to fail because things *are* harder than that," says Mary Jung, a University of British Columbia researcher who studies health behavior. Remember that lapses are normal rather than a sign that you should give up. "If you missed a day of exercise, that doesn't mean you've failed," Jung says. "It just means that tomorrow you've got to get your workout in."

Research suggests you should spend some time imagining both the successful result of your efforts *and* the specific obstacles that will stand in your way. Instead of resolving abstractly to save more money this year, for example, you might form two mental images: one might be of a larger bank balance, and the other of yourself wrestling with the decision to not join your friends at a pricey new restaurant. Studies find that after engaging in this two-step technique, called mental contrasting, people procrastinate less and tackle challenges more enthusiastically.

Find Your Own "Why"

To maximize your chances of sticking to a goal, you need to figure out exactly why you are pursuing that objective in the first place. "The 'shoulds' might get you going for a month or two, but they're not easily sustained," says Ryan, who, with his colleague Edward L. Deci, developed a model of motivation called self-determination theory. It posits that individuals feel most fulfilled when they are meeting their essential psychological needs: a sense of competence, relatedness to other people and, most important, autonomy, or the sense of freely choosing what you do.

Think about the ways your new habit will improve your relationship with your loved ones.

To meet the need for competence, look for activities that help you feel the inherent satisfaction of being good at something. Tracking your progress—by logging your practice times, for instance—is one way to bolster that sense of accomplishment.

We all strive to feel close to others, which is one reason why buddying up increases your probability of sticking with a goal. To perceive your resolution as satisfying this psychological need, think about the ways your new habit will improve your relationship with your loved ones, connect you to new people or bring you closer to your community.

The thirst for autonomy, the final pillar of self-determination theory, is so strong, Ryan suggests, that if you are motivated only by external pressure, sooner or later you are bound to rebel and sabotage your own efforts. Finding activities that meet your personal needs, on the other hand, will improve the odds that you will stay on target.

We ignore the importance of these internal motivators at our peril, as shown by research on the effect of financial incentives for losing weight. Short-term studies as early as the 1970s offered promising results, with cash rewards inducing people to shed

(The Author)

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more pounds than without the incentive. "Now we have long-term studies that show that the moment you take off the pay, people start relapsing," says Pedro J. Teixeira, a professor at the Technical University of Lisbon in Portugal who co-authored a paper describing a much more successful weight-loss intervention, published last year in *Medicine and Science in Sports and Exercise*. In the study, overweight women who had been encouraged to explore their personal motivations and to choose their own goals exercised far more, and lost significantly more weight, by the three-year mark than women who did not tap into their autonomy.

If your goal originated from an external source, you can still make it your own—and increase your chances of achieving it—by finding your personal reasons to pursue it. If a doctor tells you to watch your cholesterol, for example, you can ask yourself how your food choices help or hinder your pursuit of your larger aspirations, such as spending time with your grandchildren or traveling more. This process can help you see the external goal as a path to becoming the person you want to be, enabling you to embrace it more fully.

Teixeira sees deep-rooted, autonomous drive as the key that unlocks all the other doors to lasting change. "When adequately motivated, a person will ultimately find the single best solution for his or her problem," he says.

Take It Slow and Steady

Another key to making lasting changes is to start modestly and work up to bigger challenges gradually—the way successful running regimens urge couch potatoes to start by walking and to pick up the pace little by little over a few weeks. "It is so defeating to put effort into something and then fail," says Jung, who has worked as a personal trainer and fitness instructor. Part of her credo is: "If I don't know whether they can do it, it's not a good task for them to start with." Yet as sensible as that sounds, most people take the opposite approach—most commonly through extreme diets but also with sudden vows to practice the piano for an hour a day or to read the complete works of Charles Dickens instead of watching the latest season of *Jersey Shore*.

The gradual approach works because it boosts an essential ingredient in goal achievement: the confidence that you have what it takes to succeed despite real-world difficulties. That kind of faith is quite different from the unfounded optimism of those who overestimate their ability to resist temptation, Jung explains. Being able to overcome external challenges has less to do with willpower than with specific coping skills, such as managing scheduling problems and bouncing back after setbacks. Gradually developing these abilities—by setting modest goals that allow you to encounter manageable problems—boosts your confidence, making you more likely to persist toward your long-term ambitions.

Of course, that belief is shaken every time we stumble. People who have failed repeatedly at sticking to their goals tend to doubt their ability to accomplish anything. "To gain that confidence, you need baby steps," Jung says. For instance, if you strive to keep your home free of clutter, focus on one room—or even a countertop—at the beginning. Keep that area clean for a week, congratulate yourself, then add another area for the next week. Maintaining one pristine countertop may sound laughably easy—but that is exactly the point. By going after your target one small step at a time, you will reduce the effort it takes to ingrain new habits and improve your self-confidence naturally.

Engage Your Autopilot

Lasting change ultimately requires making the new behavior automatic. One way to start the habit-forming process is to spell out for yourself when, where and how you plan to reach your goals. For ex-

Steps to a Better Self

No matter what kind of goal you have, these tactics can help get you there.

1. Maintain Realistic Expectations
- Visualize your success along with the specific obstacles you will face.
- Avoid situations that trigger the habits you want to break.
- Forgive yourself if you slip up; keep moving forward.

2. Find What Motivates You
- Think about how making this change will help you become the person you aspire to be.
- Try to come up with fun ways to work toward your goal.
- Imagine how achieving your aim might strengthen your relationships with other people.
- Find a way to measure your progress and track your accomplishments.

3. Take Baby Steps
- Set short-term, achievable objectives that add up to big change.

4. Formulate Action Plans
- Prepare yourself for specific situations: "If I am offered a cigarette, I will say, 'No, thanks.'"
- Frame your intentions as positive actions: "I will say, 'No, thanks,'" works better than "I will not take it."
- Picture yourself carrying out your plans.

—*M.K.*

ample, if you aspire to eat three servings of vegetables every day, you might tell yourself, "When I go home, I will stop by the grocery store and buy vegetables," says New York University psychologist Peter Gollwitzer, who originated this if-then technique, called an implementation intention. The point is to create an automatic cue to prompt the behavior you want.

In a study published in 2010 in *Health Psychology,* Gollwitzer and a pair of his colleagues told a group of German women about the health benefits of eating five servings of fruit and vegetables a day. They also instructed some of the women on how to use implementation intentions and mental contrasting. These participants sustained their healthier diet for the full two years that the study ran, whereas the others reverted to their previous produce intake after a few months. Other studies showed that implementation intentions reduced teen pregnancy by 43 percent as compared with a control group in a British city with above-average rates of teen pregnancy, and English preteens likewise smoked less over two years by spelling out what they would say and do when offered a cigarette.

Some types of implementation intentions work better than others. For example, Gollwitzer recently found that tacking on a reason for your plan—as in, "When I get to the cafeteria, I will grab a salad *because* I want to be healthy"—backfires because thinking about the reason disrupts the automaticity, a result suggesting that you need to be clear on your reasons before you begin your program. Another finding is that the most effective implementation intentions are in positive form—"I *will* ignore the phone" instead of "I *will not* answer the phone." Adding mental imagery also helps; that way "the statement isn't just written down or repeated like a mantra but actually enacted in your mind's eye," Gollwitzer says.

Reach Your Holy Grail

Some of these strategies, particularly the emphasis on realistic goals, looking within and making concrete plans, are similar to those used in cognitive-behavior therapy to treat maladies as serious as anxiety and depression—which should give hope to those of us with more modest challenges. Yet Ryan emphasizes that the vast majority of people do not need therapy to change; after all, most individuals who quit smoking do so on their own.

Keep in mind that some of these tools may not be right for everyone. For instance, past research has shown that implementation intentions do not work as well for deeply ingrained habits. People who want to upend a lifelong routine may not find this technique very useful, just as others might find that their aspiration does not break down easily into smaller steps or present any opportunity for bonding. The important thing is to try a number of tactics and find what works best for you.

Lasting change is hard, but recognizing this difficulty will actually help you be more successful. It takes great effort and specific plans to form new habits, and you must not see your first lapse as a sign of failure. The goals you set should truly be your own, not based on somebody else's values. Perhaps most important, do not expect to change your ways overnight—even if the night in question is New Year's Eve. It's never the wrong time to start taking steps toward a better you. M

Visualize your goal—here saving money—and also specific obstacles that will stand in your way, such as wanting to try a restaurant with your friends. This exercise will give you a boost of motivation that will help you to stick to your plans for the long term.

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SENSATIONAL SENSES

Immerse Yourself

Your senses bridge the boundary between you and the world

A submarine, scooting through the depths, shoots sound waves to probe the mountains and valleys of the ocean floor, allowing humans to explore that inhospitable realm. The Hubble Space Telescope takes snapshots of scenes billions of light-years away, revealing vistas vastly beyond the limits of the human eye. Yet we need not venture to treacherous places to enhance our perception of our home planet. A compass tunes hikers to the earth's magnetic field, endowing them with knowledge of north and south as they wander through the woods.

All the intricately engineered metal guiding us through water, space or the wilderness pales in comparison to the machinery in your head. Your senses interrogate the physical world, collecting poignant details that inform your thoughts, actions and memory. The articles in this special report investigate how seemingly insignificant glances, whiffs and noises forge a tight bond between you and your environment.

The senses are not as easily divided into the familiar five as was once thought. Information traces unexpected paths through the brain to merge sounds with smells, produce uncanny forms of sight, and perform numerous other subtle yet astounding tasks. In tallying those abilities, we have gone far beyond a mystical "sixth sense"—we've doubled the count, and others will surely follow, as Ariel Bleicher explains in "Edges of Perception," on page 46.

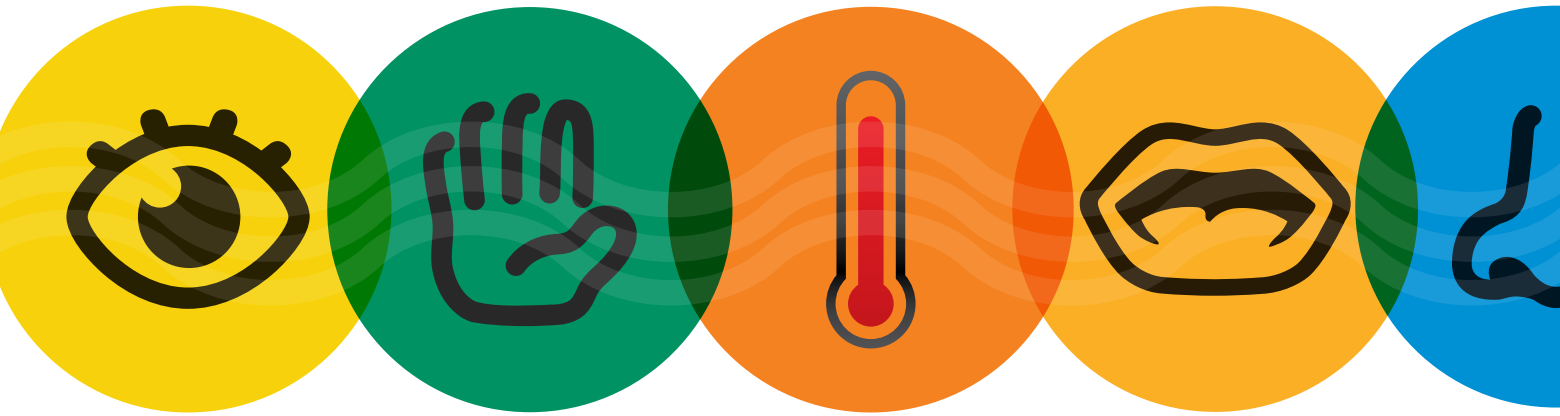
Probing the outside world also calibrates your social interactions. Observing your boss's swift gait, you held back on asking for more time on that assignment. After hearing your usually effusive neighbor's mumbled greeting, you brought over fresh-baked brownies, and a new friendship was born. In "I Know How You Feel," on page 54, Janina Seubert and Christina Regenbogen write that those emotional states would have been utter mysteries had your senses not scanned the scene.

Your built-in environmental detectors even transport you, enabling a type of time travel that a space telescope, for all its glimpses of the birth of the universe, cannot do. Maria Konnikova describes how a single sniff can bring an upwelling of long-dormant memories burbling to the surface, in "Smells Like Old Times," on page 58.

The senses imprint your surroundings on your brain. They allow the outside world to influence your thoughts and feelings, adding new dimensions to what we call our "sense" of self.

—The Editors

ILLUSTRATION BY NOMA BAR



Edges of Perception

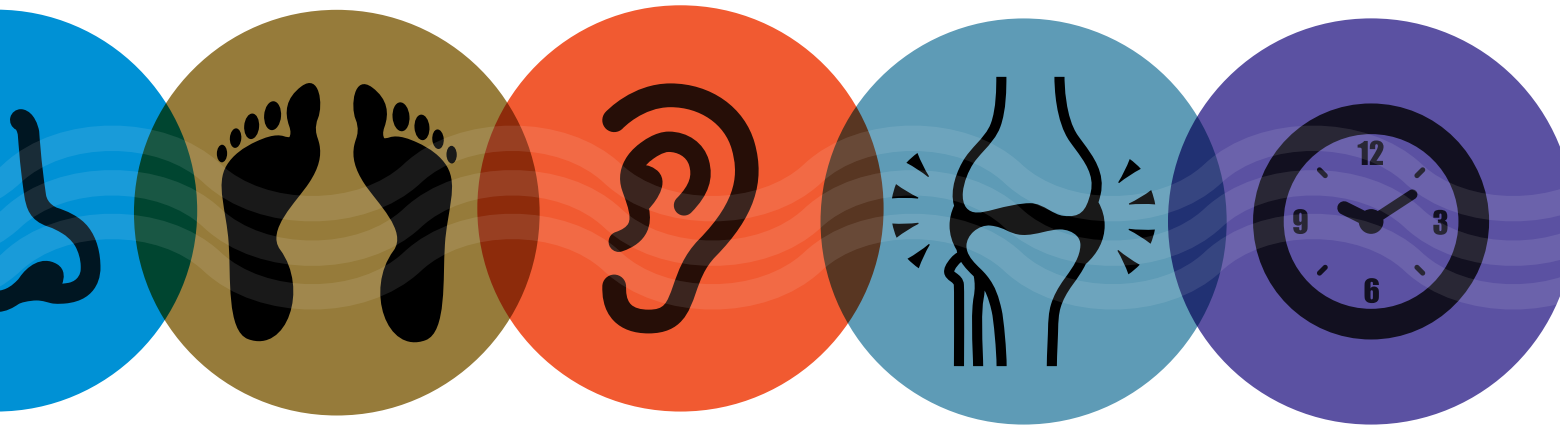
Unusual cases reveal that the

For as long as he can remember, Bryan Alvarez has thought his mother resembled a Mark Rothko painting. The likeness is not just a metaphor he conjured up one day. Whenever he conceives of her name, Marla, he literally sees, in his mind's eye, blocks of colors, each one blending into the next—grainy, brick red for the M, bright, blood red for the A, eggplant purple for the R, plum purple for the L and red again for the final A.

Growing up, Alvarez never thought it unusual that letters have inherent colors. He was in high school when he learned that his peers did not perceive the world as he did. Alvarez has a condition called synesthesia, in which otherwise normal people feel shapes when they taste foods, smell odors when they hear musical notes or see colors when they read words.

History is littered with accounts of equally strange departures from what is commonly thought of as ordinary perception—blinded soldiers who can dodge bullets, patients who can sense light without eyes and people who can navigate obstacles using sound. For centuries such stories were considered unexplained curiosities, magical gifts or neurological anomalies—exceptions to the basic rules of per-

PHOTOILLUSTRATION BY SCIENTIFIC AMERICAN MIND; ISTOCKPHOTO (*icons*)



famous "five senses" are not as distinct as once thought **By Ariel Bleicher**

ception. Only in the past few years have neuroscientists begun to suspect that we all may share some of the mechanisms underlying these conditions.

Until recently, perception was largely viewed as the handiwork of distinct senses. Greek philosopher Aristotle allegedly first classified the famous five: vision, hearing, taste, smell and touch. Over the years researchers have added many more to the list, including senses for balance, pain, time, temperature, limb positioning, and the ability to register hunger and thirst. Brain-imaging studies in the past two decades have helped researchers divvy up the senses further still, identifying neural pathways for processing numbers and letters, colors, shapes and faces. But this old model of perception is beginning to change.

"We can no longer view the brain as a bunch of specialized compartments that don't interact much," says psychologist Ladan Shams, who studies multisensory perception at the University of California, Los Angeles. Neuroscientists are discovering that our sensory systems are much more interconnected and widespread in the brain than previously thought. Vision is not just about seeing. Hearing is not just about listening. Even in ordinary circumstances, the ways our senses can inform and compensate for one another may seem exotic or even superhuman.

The Eye's Secret Back Door

Most evidence supporting a splintered view of perception comes from studies of vision. Scientists

She could adjust her sleep patterns and could even sense whether a room was bright or dark—although she claimed she could not see any source of light.

have long known that visual information travels from the eyes through the thalamus, a relay station located above the brain stem, to the visual cortex, where it gets packaged into the colored, textured, three-dimensional scenes we perceive as sight. Even so, researchers are now finding that some visual data are deployed for uses that have little to do with ordinary sight, such as keeping track of time and controlling movement subconsciously. In fact, the sensory mechanisms may be altogether different, starting with tiny, little-known light sensors in the retina.

Since the mid-1800s anatomists have known about the eye's rods and cones, and for nearly two centuries scientists believed these photoreceptors were the only cells in the human body that could detect light. In the early 1990s, however, a young researcher named Russell Foster, now at the University of Oxford, started sharing his suspicions that an unidentified type of eye cell was also responding to light and firing off very different messages to the brain.

Foster, a circadian neuroscientist, knew that the mammalian brain relies on light not just to form images but also to set its internal clock. He was aware, for example, that mice can adjust their behavior to synchronize with a new day-night cycle, just as humans do after traveling to a different time zone. Mice without eyes, however, cannot. Yet when Foster studied mutant mice lacking rods and cones, he found they could reset their clock just fine. "There *had* to be some other weird photoreceptor residing in the eye," he says. "But what the bloody hell was it?"

While Foster hunted in vain for the elusive photoreceptor, one of his former graduate students made a startling, seemingly unrelated discovery. Ignacio Provencio, now at the University of Virginia, had identified a protein that makes some skin cells in frogs darken in the presence of light. He called the protein melanopsin. He searched for it in other frog tissues and, to his surprise, uncovered it in cells of the retina. Remarkably, those cells were neither rods nor cones. "This immediately set off a lightbulb," Provencio remembers. "I thought, Aha! We might have finally identified those mythical photoreceptors we'd been looking for a decade before."

Sure enough, Provencio observed in the retinas of mice and humans that a small percentage of ganglion cells—which typically carry signals from rods and cones along the optic nerve into the brain—contained melanopsin. Other labs were intrigued by these strange neurons and did many experiments verifying their role in setting the day-night cycles of mice and rats. Then, in 2007, Foster met a woman with a rare genetic disorder that had destroyed her rods and cones but left her ganglion cells intact. He discovered that, like his lab mice, she could adjust her sleep patterns and could even sense whether a room was bright or dark, although she claimed she could not see any source of light. The evidence was glaring: hidden detectors in our eyes guide our biological clocks—and probably do much more.

By tracing the cells' messaging route into the brain, other research groups learned that their signals diverge not just to the sesame seed–size clump of neurons responsible for our circadian rhythms, called the suprachiasmatic nucleus, but also to brain centers that dilate the pupils, shift the gaze, and even regulate fear and pain. Researchers at Beth Israel Deaconess Medical Center in Boston, a teaching hospital affiliated with Harvard University, found in a study in 2010 that for blind patients who experience migraines, light intensifies the pain only when their ganglion neurons are healthy.

"It's become quite clear that there are many, many aspects of our visual system that are taking place at levels you might call reflexive, automatic or subconscious," says Brown University neuroscientist David M. Berson. The "funny ganglion cells," as Berson calls them, are just one way the brain sur-

FAST FACTS

When Senses Collide

1» **Individuals with brain damage can expose—or develop—unusual perceptual abilities that provide clues for how we all detect the world around us.**

2» **Recent studies reveal that human sensory systems are much more interconnected than previously thought.**

3» **Healthy people, too, may possess less developed multisensory skills, including basic echolocation and a rudimentary form of synesthesia.**

reptitiously collects visual cues to guide our behavior without our knowing it.

Seeing without Knowing

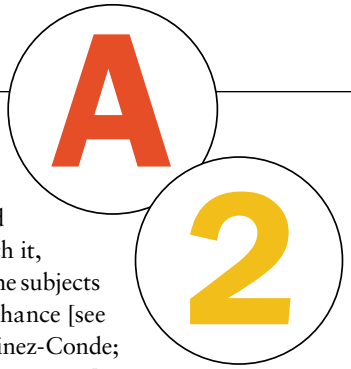
Vision can bypass conscious perception in another, even stranger way. The phenomenon is most easily observed in people with damage to their primary visual cortex, the brain's main image-processing center. In the spring of 2002, for instance, a Scottish ophthalmologist named Gordon Dutton received a visit from a young secretary who had lost her entire primary visual cortex, leaving her completely blind. As Dutton escorted her into his office, he noticed she swerved to avoid a row of chairs in the hallway.

"You walked around those chairs," he remarked. "What chairs?" she replied, puzzled. "I know you can't see them," Dutton reassured her, "but could you walk around them again?" She did and still perplexed, admitted, "I don't know how I did it." Dutton smiled and said, "That's because your unconscious visual brain did it for you."

Dutton was sure the secretary had what psychologists call "blindsight." He had read many accounts dating back to the early 1970s of patients with cortical damage who could not identify objects in parts or all of their visual field. Yet when psychologists asked them to either glance toward an object they claimed they could not see, reach out and touch it, or guess its shape or its color, many of the subjects did so correctly far more often than chance [see "Subconscious Sight," by Susana Martinez-Conde; Scientific American Mind, April/May 2008].

Researchers today explain blindsight as a kind of information detour in cortically damaged brains. With ordinary vision, the images on a retina first get mapped to neurons in the primary visual cortex, located at the back of the skull. From there the signals diverge into two distinct channels. One path taps into memory to identify objects and forms. The other leads to more evolutionarily ancient parts of the brain, some of which control reflexive movements such as catching a fastball or ducking a punch.

But when the primary visual cortex is damaged, recent imaging studies in monkeys and humans confirm, some visual information can take alternative routes. It arrives at the brain's motor centers without ever passing through the parts of the cortex involved in memory and consciousness. "This explains why you can have patients who are unable to tell you if a



People with synesthesia may perceive, for example, the letter A as red or the number 2 as yellow. In general, however, our senses are more interwoven than once thought.

The eye sends information traveling along several routes through the brain, such that even a badly damaged visual system can generate a nuanced picture of the world.

JOHN LUND *Getty Images*

Do Humans Have a Magnetic Sense?

Many animals can perceive directions and geographic location by sensing the earth's magnetic field, the invisible (to us) force that points compass needles north. Migratory animals such as birds, whales and sea turtles have evolved this magnetic sense to help them travel long distances. Scientists are, in fact, constantly turning up new examples of magnetic perception, including in flies, chickens, mole rats, lobsters, newts, sharks, rays, trout, bats, butterflies, cows, cockroaches and, most recently, foxes.

Certain animals, such as sharks, may use electricity-sensing cells located throughout their body to detect fluctuations in the earth's magnetic field. Other animals may rely on a magnetic mineral called magnetite, which has been found in the noses of salmon and trout and in the beaks of pigeons. Most birds, however, may benefit from a quantum mechanism that acts on proteins in the eye and depends on light. They may perceive magnetic fields visually—as patterns of light superimposed on ordinary vision.

Some scientists are now wondering whether humans, too, might have a magnetic sense. Neurobiologist Steven M. Reppert of the University of Massachusetts Medical School in Worcester and his colleagues recently discovered that the human eye carries a light-sensitive protein that can double as a magnetic receptor in flies. As he sees it, we may simply not be conscious of magnetic fields' effect on our vision. "Why not?" he says. "The more we look for mechanisms in humans that occur in simpler organisms, the more we find." —*A.B.*

line is horizontal or vertical, but they can orient their hand and size their grip just right to grasp a pencil in your hand," says Melvyn A. Goodale, a neuroscientist at the University of Western Ontario.

Blindsight also appears to play a role in recognizing emotions and triggering mood. In a series of studies begun in 1999 Beatrice de Gelder of Tilburg University in the Netherlands showed that some affected patients could accurately guess whether a face was happy or angry. Moreover, they could sense when body postures were threatening and even flexed their facial muscles and dilated their pupils in response—evidence, de Gelder says, that unconscious visual processing "is transporting the patient into a real emotional mood." [To learn how our senses interact with moods, see "I Know How You Feel," by Janina Seubert and Christina Regenbogen, on page 54.]

No one can say for sure whether the pathways underlying blindsight also exist in fully sighted people. De Gelder thinks they do, although they may be much less active. In a study currently in press she and her colleague Marco Tamietto of the University of Turin in Italy compared brain scans of a sighted person and a partially blindsighted patient with just one damaged hemisphere. She found the same neuronal connections between the eye and the emotion centers of the brain in both individuals. Yet the links were much stronger in the blindsighted hemisphere.

"We tend to think of brain damage as a loss of function," de Gelder says. "But we also have to think about it in terms of gaining functions that were inhibited by certain brain areas before. The human brain is like a very, very big delta: if there is a dam on a major route, then water will flow along the minor routes, and those minor routes will become wider and more functional."

Goodale and Dutton share this view of the brain. They view blindsight as any mental or physical endowment—a skill that can be trained and put to good use when needed. For example, they recently worked together to teach the blindsighted secretary to read large letters printed on a page. Although she does not consciously perceive the letters, she can trace their outlines with her finger (or imagine tracing them) and recognizes the shapes she draws in the air. "She reads the headlines of the *Times* that way," Dutton says. "Very slowly, of course."

Sonic Vision

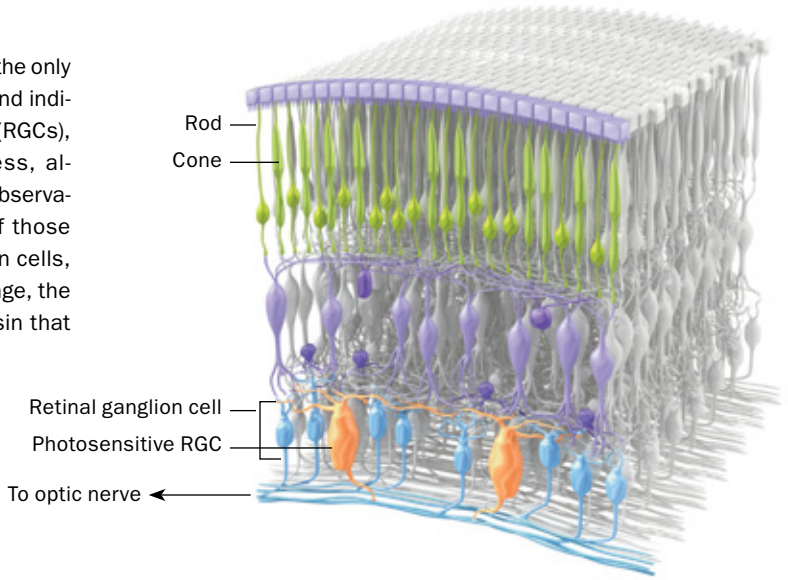
Besides rerouting messages from the eyes, the brain is also very good at substituting one sensory input for another, even using the ears to construct remarkably sightlike pictures of the world. By examining individuals who have developed this ability,

GEORGE DOYLE *Getty Images*

Sight for Blind Eyes

Rods and cones were long believed to be the only cells able to detect light in the retina. Blind individuals with intact retinal ganglion cells (RGCs), however, remain sensitive to brightness, although they are not conscious of it. That observation led to the discovery of a subset of those cells, the photoreceptive retinal ganglion cells, that also sense light. Shown here in orange, the cells produce a protein called melanopsin that enables them to detect light directly.

Retina detail



scientists are beginning to realize that the visual system may not be strictly about vision after all.

The most scientifically studied person who sees with sound is an American man named Daniel Kish. He lost his eyes to cancer when he was a year old. As a toddler, he figured out that if he made sharp, quick clicks with his tongue and listened to their echoes, he could get around his neighborhood pretty well. *Really* well, in fact. Today he goes dancing, hikes in the dark and frequently rides his bike in city traffic.

Scientists refer to what Kish does as human echolocation, although Kish describes it as "something like seeing the world in dim flashes of light." The scenes he relates have form, texture, depth and continuity, but they are colorless and their resolution is limited to "about the size of a softball."

Kish often uses the vocabulary of sight to describe his echolocation, and scans of his brain suggest this is no accident. In a 2011 study led by Lore Thaler, then a researcher in Goodale's lab at Western Ontario, scientists scanned Kish's brain, as well as that of another blind echolocator (along with two control subjects), while they listened to recordings of clicks and their echoes. Thaler also had the subjects listen to the recordings without the echoes. Comparing the images, she found that the visual cortex was active only in the echolocators and only when they listened to the echoes, not other background sounds. The auditory cortex, meanwhile, seemed to play no special role in turning echoes into images.

It is well known that when the eyes are lost or damaged, the vision centers in the brain get recruited for other tasks, such as reading braille. The visual cortex is also active when blind people use sensory substitution devices—head-mounted camcorders that translate images into sounds or tiny electrical pinpricks delivered to the skin, for example. But studies such as Thaler's suggest that the visual brain does not rent out its abandoned neural real estate simply because it is available. Rather it may learn to employ new sensory inputs to perform its usual tasks: calculating spatial relationships and composing scenes.

"We're having to rethink what the visual system really is for," says Alvaro Pascual-Leone of Beth Israel Deaconess and Harvard Medical School. Even in sighted people, he says, the visual brain may also be wired to use signals from the ears and skin. In one study, for example, he blindfolded volunteers for five days and periodically scanned their brains as they solved puzzles involving hearing or touch. By the fifth day he could observe certain vision centers becoming more engaged, and the volunteers' performance on some tasks improved. Pascual-Leone was amazed by how quickly the changes happened. Five days is not enough time for the brain to grow new circuits. It is enough time, however, to strengthen old connections and put them to use.

Even a connoisseur's nose can be tricked when a glass of white wine is dyed to appear red, showing that what we smell can depend on the context.

BRYAN CHRISTIE (*top*); JULIÁN ROVAGNATI /*Stockphoto* (*bottom*)

(The Author)

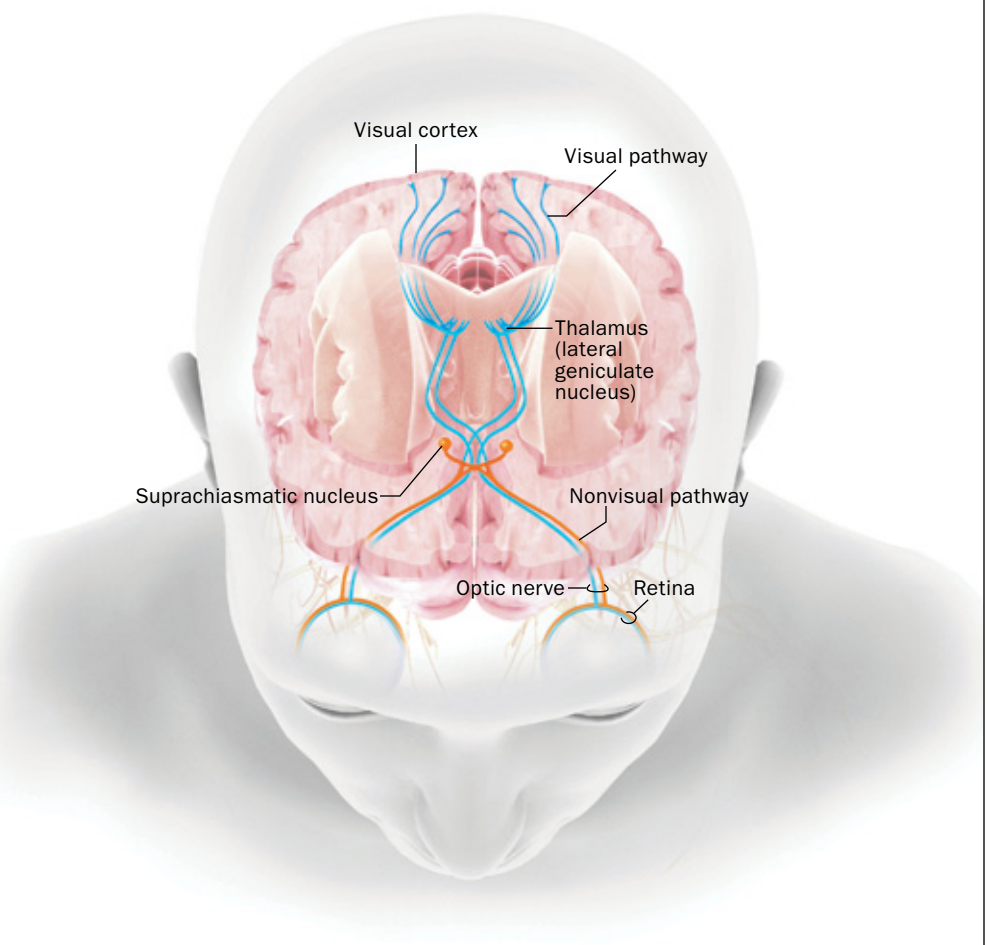
ARIEL BLEICHER is a New York City–based science journalist who has written for *Popular Mechanics*, *IEEE Spectrum* and the *Scientist*, among other publications.

Although most people do not see the colors of a Rothko painting when they read a name, they may make similar associations as synesthetes do, such as pairing high-pitched sounds with light colors, sweet tastes or spiky things.

Sighted people can teach themselves to echolocate, as a study published in 2011 showed. In it, subjects used clicks to find plastic plates in a simple lab environment, in some cases almost as well as Kish. "Just because we're sighted, it doesn't mean we're not using some component of echolocation," Pascual-Leone says. "When we're seeing, we're not purely seeing. Our seeing is flavored, among other things, by the input of sounds."

Beyond Basic Vision

The retina sends signals down more than one pathway in the brain. Most information travels through the thalamus to the visual cortex and then to regions that perform conscious processing. But some data diverge to motor centers and the suprachiasmatic nucleus, the body's biological clock, enabling certain blind individuals' unconscious ability to navigate obstacles and maintain healthy circadian rhythms.



BRYAN CHRISTIE

Mmm … Sounds Like Coffee

Echolocation, of course, is not the only instance of collaboration among the senses. If you have ever eaten a meal with a stuffy nose or watched a ventriloquist throw her voice, you know firsthand that the senses inform one another. In fact, our perceptual systems work together more often than we may realize, in ways that are far from obvious.

"The brain is constantly multiplexing information," says neuroscientist Edward M. Hubbard of Vanderbilt University. Classic studies show, for example, that watching lip movements changes the way you hear words—a phenomenon known as the McGurk effect—and that your sense of balance can alter what you see. (If you look at a straight line after twirling around in a circle, the line will look tilted.) Similarly, sensing changes in acceleration can make objects appear higher or lower than they actually are. The sensation is common among airplane pilots, who perceive the nose of the plane during takeoff as rising faster than it is.

Smell, too, is closely connected to several senses. "Even the best wine tasters' trained noses will be thrown off if you color a white wine red," says neuroscientist Daniel W. Wesson of Case Western Reserve University, who recently found evidence for a sound-smell, or "smound," sense. In a 2010 study he showed that neurons in the olfactory system in mice fired electrical pulses in response to tones as well as odors. More remarkably, some neurons had stronger or weaker responses to odors in the presence of certain sounds, suggesting that sounds fine-tune the perception of smell. [To learn how scents interact with memory, see "Smells Like Old Times," by Marina Konnikova, on page 58.] For some people the senses are so en-

ISTOCKPHOTO

twined that experiencing one can invoke another, as is the case with synesthesia. For a synesthete, a sip of spearmint tea might have the texture of a glass column, or the note F-sharp might sound distinctly green. The most common form—the kind Bryan Alvarez has—is known as grapheme-color synesthesia, in which people perceive particular colors for letters or numbers. Most instances of the condition are very likely caused by the cross wiring of brain regions that sit close together but do not normally interact. Why these interplays exist in so many people, however, remains something of a mystery.

One theory builds on the observation that we are all born with far more neuronal connections than we end up with as adults. As our brain develops, the connections we use grow stronger and more active, whereas the rest weaken and can be lost altogether. Infants, therefore, may perceive the world much the way synesthetes do. In a 2011 study, for example, psychologists Katie Wagner and Karen R. Dobkins of the University of California, San Diego, found that babies two to four months old made associations between certain colors and shapes. Eight-month-olds, however, did not, suggesting they had already shed the links among the processing centers for colors and shapes. Because the condition runs in families, a genetic component may determine who retains some of the connections.

There is also evidence that although most people do not consciously see, say, the colors of a Rothko painting when they read a name, they still are inclined to make similar associations as synesthetes do. For example, most people tend to pair high-pitched sounds with light colors, sweet tastes or spiky things and to couple low-pitched sounds with dark colors, sour tastes and round items.

"We think we experience the senses separately," says Lawrence Rosenblum, a psychologist at the University of California, Riverside. In reality, the brain links and synchronizes sensory information from many sources in ways we cannot consciously observe, giving us extraordinary gifts we never knew we possessed for perceiving the world. M

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I Know How You Feel

Good social skills depend on picking up on other people's moods—a feat the brain performs by combining numerous sensory clues

By Janina Seubert and Christina Regenbogen

When someone approaches you to ask, "What's wrong?" you know that you are broadcasting unhappiness, whether or not you said a word. Perhaps it was a grimace or your sluggish gait that conveyed the message. You cannot help but communicate your mood to colleagues, neighbors and fellow commuters through numerous subtle cues.

Sensing the emotional states of others is an important part of social interaction. If you could not do this well, you might end up incongruously slapping the back of a person who is teary or stopping an anxious co-worker on his way to a meeting. People with autism and schizophrenia find it virtually impossible to detect other people's feelings and as a result have extreme difficulty relating to others.

Being a master of these social hints is critical to success in many domains. You can solidify friendships by recognizing when a person is sad and doling out appropriate comfort, for example. To succeed in business, you also need to accurately detect the sentiments of other people when pitching a new idea or deciding when to ask for a promotion. National security can even hinge on sensing emotions. In the U.S., millions of dollars are spent every year on training law-enforcement and security officials to read feelings in people's faces. Suspects who are faking, say, regret or calm might, after all, be hiding a criminal act or the intention to commit such an act.

In the past, scientists focused largely on the muscles of the face and a region of the brain responsible for detecting facial features. Lately, however, researchers have found that contextual cues—including a person's posture, the tone of his or her speech, and the attitudes of bystanders—are critical to emotion perception. By pinpointing the regions of the brain that subconsciously assemble those clues within milliseconds, scientists are now beginning to understand how our senses shape our social skills.

FAST FACTS

Reading Emotions

1» **Understanding what others are feeling, thinking and wanting is essential to successful social interaction.**

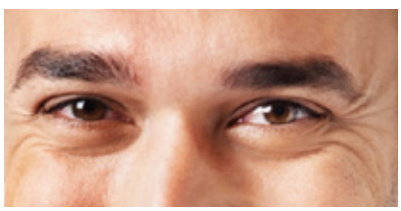
2» **We sense the emotions of others by combining disparate clues: expressions, gestures, body posture, tone of voice and even odor.**

3» **Scientists have fingered brain regions that integrate disparate sensory signals that may be associated with a particular person or scene.**

Face First

In pioneering studies on emotion perception back in the 1970s, psychologist Paul Ekman and Wallace V. Friesen, then both at the University of California, San Francisco, classified expressions by what they called "facial action units," which consist of combinations of physical changes in the face. For example, to generate a smile we raise the sides of our mouth and contract muscles that create wrinkles at the corners of our eyes. Some two decades later psychologist Nancy Kanwisher, now at the Massachusetts Institute of Technology, and her colleagues identified a blueberry-size region in the brain, the fusiform face area (FFA), that responds specifically to

HUGH KRETSCHMER *Getty Images (man with bubble)*; HELDER ALMEIDA *iStockphoto (feet)*; ABEL MITJA VARELA *iStockphoto (eye and smile)*; ISTOCKPHOTO *(back)*



faces [see "A Face in the Crowd," by Nina Bublitz; Scientific American Mind, April/May 2008].

In reading the emotions of others, the FFA collaborates with the amygdala, a processor of emotions. In 2001 neurologist Patrik Vuilleumier of the University of Geneva and his colleagues found that an individual's amygdala responds to the appearance of fearful expressions even if that person is paying attention to something else. The FFA also responded more strongly to fearful than neutral faces, suggesting that the amygdala sends feedback that can augment the firing of neurons there.

We can't always infer a person's mood from her face alone. Close-up, tennis player Serena Williams appears hurt or angry. But when we step back and look at the athlete's body language, she is clearly exultant after a major victory on the court.

Yet researchers now know that faces alone do not always betray feelings with great fidelity. As a result, we typically evaluate an expression's context, including body posture, surrounding faces and tone of voice. The combination, it turns out, makes our judgments more reliable. Faces that in isolation appear contorted in disgust look proud when they are attached to a muscular physique with arms raised in triumph. What seems like a scowl may instead signal fear if it accompanies a description of danger. In the close-up of tennis player Serena Williams's face in the left illustration above, she looks either angry or pained. But zoom out (*above, right*), and you see she is clearly triumphant after a big win at the 2008 U.S. Open.

(The Authors)

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The more ambiguous the expression, the more we look to other information. Researchers have begun searching for regions of the brain that can interpret all the incoming data—and then solicit more, if necessary. Neurons in such "convergence zones" would need to respond to more than one type of sensory cue—sound as well as sight, for example—and identify them as arising from a common source, taking the first step toward gaining insight into another person's mind.

Sensory Switchboards

In a study published in 2000 psychologist Randy L. Buckner, then at Washington University in St. Louis, and his colleagues found evidence for one such zone. The researchers exposed volunteers to word fragments either by displaying them on a screen or by playing their sounds. The scientists asked them to assemble the pieces into words as quickly as possible while inside a brain scanner. Regardless of whether the subjects saw letters or heard their sounds, the words came faster when the fragment was presented a second time. Accordingly, parts of the prefrontal cortex charged with forming abstract thoughts reacted to repeats more weakly than they did to novel fragments, which suggests a boost in brain efficiency the second time around. Because these regions showed the same response for both visual and auditory input, they satisfied the criteria for a region that could integrate different streams of sensory information to yield an overall impression of an object or scene.

Analogous brain regions seem to assimilate emotional stimuli. In a 2010 study Vuilleumier and his colleagues monitored brain activity while volunteers viewed or listened to actors expressing five different emotions: anger, disgust, happiness, fear or sadness. The actor expressed each emotion with his or her body (and the face obscured), face (with the body out of view) or tone of voice (with no visual input). The participants then rated how intensely they thought the actor was feeling the emotion portrayed.

The researchers were able to pinpoint two brain regions whose responses appeared to represent the feeling rendered independent of whether the face, body or voice conveyed the mood. These were the medial prefrontal cortex, a part of the social brain involved in understanding others' intentions, and the superior temporal sulcus, a groove in the temporal lobe involved in perceiving biological motion and the direction of a person's gaze [*see box on opposite page*]. These cerebral hotspots may serve as part of the switchboard that gathers and analyzes data relevant to recognizing emotion in others.

BARTON SILVERMAN *Redux Pictures*

Odor perceptions seem to join other sensory data to form a swift impression of a person's feelings. In a 2010 study one of us (Seubert), then working in Ute Habel's group at RWTH Aachen University Hospital in Germany, and our colleagues decided to analyze how the brain registers disgust, which can be difficult to recognize by a face alone. We asked people to identify feelings from pictures of expressive faces—disgusted, happy or neutral—while inside an MRI scanner. Along with the pictures, participants were exposed to either pleasant or repulsive odors piped to their nose through narrow tubes.

If an unpleasant odor accompanied a disgusted expression, people recognized the revulsion much faster than they did with the face alone. As expected, odors did not speed up recognition of happiness. We found that the presence of an unsavory odor diminished activity in the FFA, suggesting that smell helps the brain process emotions more easily. We found similar decrements in responsiveness in prefrontal brain areas and in the insula, which encodes disgust. Because sights and sounds also activate regions of the prefrontal cortex, these results bolster the idea that the brain contains a network of regions responsible for weaving together the emotional messages embedded in several types of sensory data.

Lower Thoughts

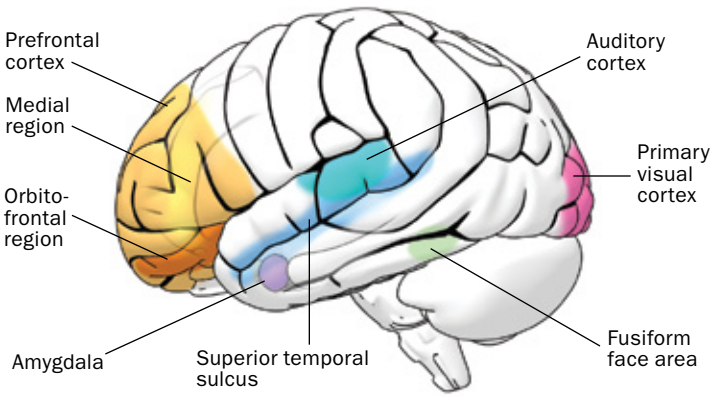
Not all of that sensory blending occurs at a high level in the brain, however. More basic cross talk between senses may also take place; for example, regions dedicated to sound perception may respond to the sight of moving lips. In 2002 a team led by psychologist Sophie Molholm of the Nathan S. Kline Institute for Psychiatric Research in Orangeburg, N.Y., reported detecting brain-wave patterns indicative of early interactions between sensory components. The researchers asked volunteers to press a button as soon as they either saw a circle on a screen or heard a high-pitched tone. In some instances, a circle was accompanied by the tone. When the stimuli were simultaneous, people reacted significantly faster. The combination of sight and sound boosted the amplitude of a particular brain wave that appears within 50 milliseconds of a novel stimulus, beyond what the sum of the equivalent individual visual and auditory signals produced. Because a neural message from the eyes requires at least 50 milliseconds to travel to the first stage of processing in the brain, these results suggest that visual and auditory cues combine long before they reach the front of the brain.

In light of this and other evidence, scientists believe the brain deciphers emotional content in several stages. Its quick and dirty assessment, orchestrated largely by the amygdala, can combine related stimuli to initiate gut responses when a situation requires immediate action. Later, frontal brain regions may perform a more detailed analysis to guide more deliberate behavior.

Whatever goes on in the brain, knowing that emotion perception involves knitting together an array of sensory input may help us read others more accurately. Software that can interpret the emotional cues in facial expressions and tones of speech already exists, and in the near future these technologies or other types of training regimens could help teach autistic individuals, people with schizophrenia or others who are poor at detecting feelings what to look for in social situations. For the rest of us, we should be aware that getting a good handle on another person's mood may mean taking a step back to see what that smirk, smile or furrowed brow really means. The posture, manner of speaking or aroma that accompanies that facade could tell us all we need to know. M

The **Social** Brain

Perceiving emotion in others requires the collaboration of disparate brain regions. To read feeling in a face, the amygdala, an emotion hub, works with the fusiform face area, which is dedicated to face recognition. The medial prefrontal cortex and superior temporal sulcus read mood regardless of whether the cues come from a face, body or voice. They receive data from visual and auditory cortices, which process sights and sounds.



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GEORGE RETSECK

Smells Like Old Times

Our sense of smell sways our memory and thought

By Maria Konnikova

Six years ago, on an early morning in September, Molly Birnbaum was out for her regular jog when she was hit by a car. Her pelvis was shattered, her skull fractured, her knee torn. Yet for her, the most serious damage was far less visible: she lost her sense of smell. Birnbaum, now 29, was an aspiring chef, and the loss meant the end of her career. It also meant something else, something that was potentially even more life-changing. "I felt like I lost a dimension of my memory," she says. "It made me worried about the future. If I couldn't smell ever again, was I losing this important layer?"

Memory comes in many forms. Every day we constantly receive and process sights, sounds, touches and smells from our surroundings, some of which will become our memories. The nature of those recollections, however, is inconstant. One memory can seem immediate and colorful, as if the event had just occurred, whereas another must be coaxed out of our brain little by little. Although a moment that excites our emotions is more likely to be recorded than a routine experience, the sensory qualities of the event we have buried in our brain also plays a part in how vividly and accurately we remember something.

Although sight dominates our daily life, it has long been thought that smell might have a privileged relation with memory. Until relatively recently, however, the precise nature of that connection remained largely unexplored. Now scientists are revealing that recollections tied to smell can be stronger than memory of other types. Olfaction can transport our thoughts back to some of our earliest experiences and tint these remembrances with feeling. On the flip side, its absence could be a sign—and potentially a cause—of cognitive decline. Scientists are at a very early stage of developing therapies to train people to smell better, which could one day stave off the deterioration of mental faculties.

Transported by Scent

Aristotle explored the apparent ties between odor and memory in his treatise from the fourth century B.C., *On Sense and the Sensible*. Since then, people have speculated that the memories elicited by smell are more intimate and immediate than other recollections. When we experience certain smells, we often find ourselves whisked back in time to a specific event or scene. For example, the smell of salsa reminded Birnbaum of watching James Bond movies on television with her dad while dipping chips in the spicy sauce. When she lost her sense of smell, she could still remember eating salsa with her

ANN E. CUTTING

Odors tend to trigger memories of early life experiences, such as baking sugar cookies with your mom.

father, but she could no longer quickly summon that long-ago scenario.

Psychology studies support the idea that memories associated with odors are unusually evocative.

Memories tied to odors are both older and associated with more time travel–like experience than are recollections of other kinds, research suggests.

In a 2006 experiment psychologists Johan Willander and Maria Larsson of Stockholm University gave older adults one of three types of cues—visual, auditory or olfactory—and asked them to describe an autobiographical event that came to mind as a result. The participants also rated the event based on its emotionality, vividness and importance.

Although the volunteers came up with the same number of memories for each type of cue, odors elicited earlier memories, including far more from the first 10 years of life, than did sight or sound cues. Recollections emerging from scents were also associated with a stronger feeling of being brought back in time. The results suggest that memories tied to smell are both older and associated with a more time travel–like experience than are other types.

The use of odors to trigger memories has led researchers to reconsider the long-held notion that people recall more incidents from their teens and 20s than from any other time in their life. In 2000 psychologist Simon Chu, now at the University of Central Lancashire in England, and his colleagues discovered that although visual memories did peak between the ages of 11 and 25, odor-cued recollections crested between the ages of six and 10.

Rachel Herz, a cognitive neuroscientist at Brown University, sees olfaction as a potential key to a trove of past experiences that would otherwise remain locked. A whiff of a smell not encountered since childhood may bring us back to an event that we had all but forgotten existed, she theorizes.

Smell might have this power because odors themselves are relatively rare, compared with, say, visual stimuli. Every day our eyes are constantly bombarded with images, many of which are quite similar, cre-

GETTY IMAGES

FAST FACTS

The Nose Knows

1» Recollections tied to smell can be stronger than memories elicited by other cues.

2» Most visual memories hark back to when people were in their teens and early 20s, but the greatest number of odor-related recollections come from when we were six to 10 years old.

3» An impaired sense of smell may be a sign of cognitive decline and might even hasten memory loss.

ating confusing interference in the brain. In contrast, our nose detects distinct odors only infrequently, a fact that Richard L. Doty, director of the Smell and Taste Center at the University of Pennsylvania, surmises is key to the evocative power of scent. Because smells are encountered rarely, individual odors are often tied to a unique experience, enabling a strong and stable connection.

Smell has a privileged relation with memory on an anatomical level as well. It is the only sense that connects with the memory system without stopping over in the thalamus, a sensory relay station. Signals travel from the nose to the olfactory bulb and then directly to the hippocampus, an essential hub of memory formation, and the amygdala, which processes emotion. "Memory and odors are just sitting side by side," says research psychiatrist Donald Wilson of New York University Langone Medical Center.

The connection does not end there. In a parallel track, the olfactory bulb passes information to the olfactory cortex, which sits at the surface of the brain just above the ears. Part of this region is involved in complex learning and memory tasks. The olfactory cortex, together with an adjacent decision-making area, the orbitofrontal cortex, processes the information contained in a smell and sends the data back to the hippocampus. This back-and-forth communication ties scents with remembrances.

Sniffs of Young Noses

To understand why odors seem to strongly evoke very early life experiences, scientists began to search for other differences in how the senses interact with memory. In 2009 neuroscientist Noam Sobel of the Weizmann Institute of Science in Rehovot, Israel, and his colleagues taught subjects to pair pictures of objects with a smell or a sound, or both. Subjects then viewed pictures of the objects while in an MRI scanner and were asked to recall either the smell or sound associated with each image. In a second round, the researchers paired every object with an opposing odor or sound or odor-sound pair: if the first stimulus had been pleasant, this time, it was unpleasant—and vice versa. Another brain scan and test of these memories followed.

One week later the researchers presented the pictures a third time and asked participants to name the odor or sound that popped into their mind. Overall, people recalled the memories from the first round slightly more than those in the second set. The brain scans, however, produced a more nuanced picture. When a person thought of the first odor, the hippocampus became much more active than when he or she remembered the second smell, suggesting that the brain issues a special tag for first odor associations. In contrast, the hippocampus activity was the same for first and second sounds.

In addition, on the first memory test, the more the hippocampus responded during odor retrieval, the more likely a person was to later remember that first odor as opposed to the second. No such relation existed for sounds. Given the brain's unique response to first odor memories, the smells of childhood may make early remembrances particularly durable.

Although its effect on our earliest recollections may be most pronounced, smell might also facilitate learning more broadly. In a study published in 2007

BEAU LARK *Corbis*

Whiff of Melancholy

In addition to unleashing emotions from the past, the ability to detect scents also seems to influence a person's current mood. Psychologist Bettina Pause, now at Heinrich Heine University in Düsseldorf, Germany, and her colleagues have shown that individuals who suffer from depression have a blunted sense of smell. Although it is not clear whether that sensory loss fed the depression or resulted from it, many researchers believe the influence runs in both directions.

For example, some data suggest a bad mood can impair smell. In a 2007 study a team led by psychologist Olga Pollatos, now at the University of Potsdam in Germany, coaxed participants into one of three emotional states—positive, negative or neutral—and then measured their sensitivity to an odor. The researchers found that the people in a negative emotional state had reduced sensitivity to the odor as compared with those in a neutral or good mood.

Anecdotal reports also hint that a loss of smell can spawn sadness. For instance, surgery in the nasal cavities to remove polyps often leads to mild depression, psychiatrists say. As a result of such observations, cognitive neuroscientist Rachel Herz of Brown University believes people can get into a "depression-olfaction loop": sadness suppresses smell, and that sensory loss, in turn, deepens the depression.

The loss of emotional balance may subsequently affect a person's ability to learn and form memories. Depression is often accompanied by a decline in both memory and learning ability. Sufferers have a smaller hippocampus, a key memory center, than nondepressed people and, as a study published in 2010 suggests, a smaller olfactory bulb. —*M.K.*

(The Author)

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neuroendocrinologist Jan Born and his colleagues at the University of Lübeck in Germany asked people to inhale the smell of a rose while studying the locations of 15 pairs of cards on a computer screen. When the participants went to sleep that night in the lab, some of them were exposed to the rose odor, whereas others' sleep was unscented. In the morning, all the participants were tested on their memory for the card locations. Those who had been exposed to the flower fragrance remembered 97 percent of them, compared with just 86 percent for those who had received an odorless stimulus, suggesting that odors can boost learning as memories are consolidated during sleep.

Waiting to Inhale

The memories that smell evokes also have a distinct emotional tint. In studies in which Herz and her colleagues asked people to rate the poignancy of various memories, those provoked by odors were steeped in more feeling than those brought to mind by visual, verbal, tactile and auditory cues. In these studies, the subjective responses of emotion jibed with physical changes, such as heart rate.

Consistent with the anatomical portrait of smell, odors also uniquely recruit brain regions that process both emotion and memory. In a 2004 study Herz's team asked participants to identify a perfume that elicited a pleasant personal memory. One month later the people were shown a picture of the perfume as well as a photograph of a different perfume—and exposed to the odor of each—while inside a brain scanner. The researchers found that the odor related to the emotional memory generated more activity in the amygdala than did the pictures or the other odor. These chosen odors were also the only cues that boosted the neural response in memory-related regions. The brain's response thus mirrors people's subjective impressions that odors possess a unique power to summon emotional memories.

Accordingly, the loss of smell seems to have ripple effects on the integrity of memory and emotion centers. In studies published in 2010 and 2011 re-

ELENA SCHWEITZER /*Stockphoto*

Exercising your sense of smell may be able to improve it. One woman who had lost this sense in an accident got it back after studiously sniffing familiar foods and spices. The practice may have contributed to her recovery.

searchers at Friedrich Schiller University of Jena in Germany saw shrinkage of neural tissue in both the hippocampus and emotional brain structures in individuals with anosmia (the inability to perceive smells) and parosmia (the distortion of smells), as compared with people with no smell impairments, hinting that a loss of smell may impair memory or emotional processing, or a combination of both.

Such effects might explain Birnbaum's impression that her anosmia, though not wiping out her memory, stripped her recollections of their poignancy. "I'd always had memories that came from smell that were really important to me," Birnbaum recalls. After the accident, "I didn't forget them, but the emotional potency wasn't there." Smell's ties to emotion also become apparent in cases in which the loss of smell leads to depression—or depression leads to the loss of smell [*see box on page 61*].

Although it is not clear whether olfactory deficits directly impair cognition, they are often an early sign of a declining mind. In 2009 research psychiatrist Monica Z. Scalco and her colleagues at the University of Toronto found that poor performance on a standard test of smell could serve as a very early indicator of cognitive decline in older people. Olfactory deficits in these individuals appear to precede cognitive impairment. Complete loss of smell is also a signature of incipient Alzheimer's disease. In 2010 neurosurgeon Qing Yang and his colleagues at Pennsylvania State University reported that they could use functional MRI to detect subtle deviations in the activity of the olfactory system in Alzheimer's patients that were not present in people without the disease. In the future, doctors might look for such changes to predict the onset of Alzheimer's at a very early stage.

Exercise Your Nose

No one yet knows whether improved detection of odors can enhance cognition. Given that it might, however, scientists are looking at the possibility of shoring up people's sense of smell. In some cases, exposure to an odor can improve its detection. Take androstenone, a steroid found in sweat and urine. About one third of us cannot smell it at all, and for the rest, it smells like either sweaty socks or vanilla, depending on an individual's genetic makeup. In 2002 a group led by Joel Mainland, then at the University of California, Berkeley, demonstrated that exposing insensitive individuals to androstenone for 10 minutes daily for 21 days gave them the ability to pick up its scent. The researchers' data suggest the changes occurred in olfactory brain systems rather than in the nose itself.

In findings published last November, Wilson and his colleagues revealed that rats could gain or lose the ability to smell the difference between two similar chemicals, depending on the circumstances. The results hint that, as with rats, humans may be able to learn or unlearn how to smell as a result of everyday experiences. If we then inadvertently lose our ability to distinguish among odors—say, as a result of inattention or lack of practice—data suggest that the loss may affect other parts of our brain. Those of us who end up with declining olfactory abilities may be at risk for a loss of mental acuity or changes in our memories.

Regular exposure to odors from childhood on—or more mindful attention to existing odors—might thwart a subtle erosion of cognition.

As a remedy, some kind of smell training might help ward off such a decline. Doty believes that regular exposure to odors from childhood on—or more mindful attention to existing odors—might thwart a subtle erosion of cognition. In addition, people might be systematically tested for loss of smell just as they are examined for hearing and sight impairments now. "It could be a warning sign if olfaction falls off," Doty says.

Although recovery from anosmia is rare, Birnbaum did regain her sense of smell. No one knows why, but her exposure to odors may have helped. She studiously inhaled odors—from jars of condiments, familiar foods and spices—wherever she went. Birnbaum's brain has not totally rebuilt its memories surrounding these scents. The young woman's early-life flashbacks remain devoid of the expressive color they once had, she says. But in time, as her brain restrings the wires between nose and brain, the salsa may viscerally summon the television once again. M

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The Truth about Pot

Marijuana use can be problematic but only rarely leads to addiction

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

IN THE CLASSIC 1936 cult film *Reefer Madness,* well-adjusted high school students who try marijuana suddenly sink into a life of addiction, promiscuity, aggression, academic failure, homicide and mental illness. The movie concludes with the ominous warning that "The dread marijuana may be reaching forth next for your son or daughter … or yours … or YOURS!" Newspaper headlines of the day often reflected a similar sentiment. On February 10, 1938, a headline in the *Beloit* (*Wisc.*) *Daily News* read, "Authorities Warn against Spread of Marijuana Habit—Insanity, Degeneracy and Violence Follow Use of Weed."

Such a position on pot seems extreme. Yet just as people have since cast aside the notion that marijuana use inevitably culminates in the destruction of the mind, so have they also begun to question the concept that it is benign. In particular, some evidence suggests that marijuana can, in some cases, be addictive and that it may present other health problems as well, particularly in heavy users. That said, most people suffer no ill effects from a single or occasional use of the drug.

How Many Get Hooked?

Marijuana, which is also known as cannabis, is the most widely used illicit substance in the world, according to a United Nations report from 2002. Recreational use is widespread in the U.S., and medical use is on the rise. In a 2007 study psychologist Louisa Degenhardt of Michigan State University and her colleagues found that 43 percent of U.S. adults aged 18 or older have tried marijuana at least once. Many adolescents are drawn to the drug as well. In the large, ongoing Monitoring the Future study, researchers at the University of Michigan found that 14 percent of eighth graders had used marijuana at least once in the previous year with the number increasing to 35 percent for 12th graders. Marijuana use will undoubtedly grow in the near future because 16 states have already legalized it for medical use, and many more are considering legislation that would make it legal.

Given the drug's growing popularity, many people have long been concerned about its potential dangers and, in particular, whether it can be addictive. People tend to use "addiction" and "dependence" interchangeably, although drug experts now favor the term "dependence." In the current version of the mental health profession's "bible," the *Diagnostic and Statistical Manual of Mental Disorders*, a diagnosis of cannabis dependence (a type of substance dependence) requires a person to meet at least three of seven criteria [*see box on opposite page*].

A number of investigators have addressed this issue and found that only a relatively small percentage of those who try marijuana will become addicted. For example, in a large-scale survey published in 1994 epidemiologist James Anthony, then at the National Institute on

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); SÉBASTIEN THIBAULT (*hand with leaf*)

Drug Abuse, and his colleagues asked more than 8,000 people between the ages of 15 and 64 about their use of marijuana and other drugs. The researchers found that of those who had tried marijuana at least once, about 9 percent eventually fit a diagnosis of cannabis dependence. The corresponding figure for alcohol was 15 percent; for cocaine, 17 percent; for heroin, 23 percent; and for nicotine, 32 percent. So although marijuana may be addictive for some, 91 percent of those who try it do not get hooked. Further, marijuana is less addictive than many other legal and illegal drugs.

Possible Perils

A hotly debated issue is whether marijuana is a "gateway" drug, leading to the use of more dangerous substances. Many studies have found that most people who used other illicit drugs had, in fact, used marijuana first. Although results such as these are consistent with the gateway hypothesis, they do not prove that using marijuana causes the use of other drugs. Those who are drawn to marijuana may simply be predisposed to drug use in general, regardless of their exposure to pot. In addition, individuals often smoke cigarettes or drink alcohol before they latch on to marijuana. Should we also be asking whether nicotine and alcohol are gateway drugs?

Researchers have also demonstrated that *heavy* marijuana use can lead to increased tolerance and withdrawal symptoms when trying to stop. In addition, heavy use can contribute to respiratory and cardiovascular problems as well as impairments in short-term memory. Marijuana may also trigger certain disorders, such as schizophrenia, in vulnerable persons [see "A Mind in Danger," by Victoria Costello, on page 30], although researchers continue to debate the evidence on this issue. Finally, because marijuana is still illegal in most states and under federal law, people who possess or sell marijuana may face legal consequences.

On the other hand, marijuana has significant upsides for individuals with certain illnesses. In glaucoma patients, it can reduce the dangerously high eye pressure that can lead to vision loss. In addition, pot can provide relief from chronic pain, reduce nausea and vomiting from cancer chemotherapy, and limit the severe weight loss that results from AIDS and other diseases.

When a person does become addicted, several types of psychotherapy can help him or her kick the habit. One of the more effective types is a form of cognitive-behavior therapy (CBT) tailored to the addictive mind-set. Using CBT, therapists teach patients practical coping skills that lead to a change in behavior. They also try to modify the thoughts that contribute to a person's addiction. Two faster treatments are motivational interviewing and the closely related motivational-enhancement therapy. The goal of these methods is to boost a person's drive to stop or reduce their use of pot.

Unfortunately, relapse rates remain high for all addiction psychotherapies. In a study published in 2003 psychologist Brent A. Moore, now at Yale University, and his colleagues found that 41 percent of successfully treated marijuana addicts had relapsed within six months. Scientists are searching for ways to bring about long-term abstinence more consistently.

The public needs to be aware of the facts about marijuana so that it can dismiss fictions about the drug's effects. Only by knowing when marijuana presents a real threat and when the risk is minimal can people properly weigh its dangers and benefits in specific situations. Both our health and sound social policy depend on it. **M**

Diagnosing Dependence

If you have experienced three or more of these symptoms in the past year, you qualify as dependent on, or addicted to, marijuana. Note that you can meet this requirement without developing tolerance or suffering withdrawal.

- ☐ You need to use more of the drug over time to obtain the same effects—a phenomenon known as tolerance.
- ☐ You feel anxious, have problems sleeping or experience other unpleasant symptoms when you try to stop using marijuana. This reaction is called withdrawal.
- ☐ You are using the drug in larger amounts or for longer periods than you intended.
- ☐ Your attempts to reduce or control your use of marijuana have failed.
- ☐ You spend a lot of time trying to get the drug, using it or recovering from its effects.
- ☐ You give up important activities such as work, social events or recreation to use marijuana.
- ☐ Your use of the drug continues despite the fact that the habit is making a physical or psychological problem worse.

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Send suggestions for column topics to editors@SciAmMind.com

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The Nuts and Bolts of Emotional Sobriety

When to engage with negative feelings and when to ignore them

BY WRAY HERBERT

ONE of the cornerstones of alcoholism recovery is a concept called emotional sobriety. The idea is that alcoholics and other addicts hoping to stay sober over the long haul must learn to regulate the negative feelings that can lead to discomfort, craving and—ultimately—relapse. Doing so is a lifelong project and requires cultivating a whole new way of thinking about life's travails.

But the recovery literature also says "first things first"—which simply means "don't drink." Especially in the early days of recovery, alcoholics are counseled not to analyze why they are addicted or how they might have avoided alcoholism: "Don't think and don't drink" is the maxim. Take it one day at a time and do whatever works—prayer, exercise, meetings—to distract the mind from the compulsion to pick up a glass.

These approaches represent two very different kinds of emotional regulation, when you consider it. Distraction is unthinking—it amounts to cognitive disengagement from thoughts of alcohol and the anxiety of craving by any means possible. It is a blunt instrument in the toolbox of recovery. In contrast, long-term emotional sobriety requires the slow, steady rethinking about all the people, places and things that once did—and could again—throw us off kilter. New research suggests that a healthy mind deftly flips between these techniques when facing unpleasant emotions. By studying these mechanisms, researchers are beginning to understand how people cope with painful feelings and what goes wrong when those skills are missing.

Recovery programs teach these fundamental principles of emotional regulation because addicts do not know them intuitively. But the techniques apparently do come naturally to many healthy people. At least that is the conclusion of some recent studies by psychological scientist Gal Sheppes of Stanford University and his colleagues who have been examining the strategies that people choose for dealing with negative emotions of different kinds and intensities. The researchers had the idea that people process different kinds of emotional information in the two ways described in recovery litera-

MATT MENDELSON (*Herbert*); BLAIR KELLY (*man and clouds*)

Volunteers were much more likely to **try distracting themselves** when they anticipated a strong and intensely painful shock.

ture—either by blocking it entirely or by thinking about it carefully in an effort to reevaluate it. For example, if an experience or thought were especially intense and threatening, people would nip it in the bud early. They would simply disengage and not pay attention, in that way blocking negativity from awareness, much as newly recovering alcoholics are advised to do. This technique would keep potent negative thoughts from ever gaining force.

Distract Me

People faced with milder negative emotions, on the other hand, would not block them out. These emotions would be regulated by a second cognitive mechanism, which applies more elaborate processing to these unpleasant feelings in an effort to render them harmless. But first, the negative thoughts and emotions must be stored in memory for reappraisal and reinterpretation. At least that is Sheppes's theory, which he and his colleagues tested in a series of laboratory experiments. They hypothesized that healthy people would tend to distract themselves quickly from intense emotional experiences, and in contrast, they would tend to engage with milder, less threatening experiences to diffuse their emotional power.

The researchers recruited 20 volunteers and instructed them on the two methods of emotional regulation—distraction versus reappraisal—then had them view photographs depicting negative emotions of different intensities. A low-intensity image, for example, might show a woman holding her head in an ambiguous state of distress, whereas a high-intensity photograph might show a woman in extreme distress, with blood streaming down her face. The volunteers looked at a series of such pictures, gazing at each for half a second then narrating out loud for five seconds how they were processing the emotion—whether they were distracting themselves from it or thinking about how to reinterpret it. Other volunteers and observers characterized the subjects' regulatory strategies as either distraction or engagement and reappraisal. Just to be sure the results were accurate, the subjects also pressed a button to indicate which emotional processing style they were using.

The results were unambiguous. Most of the volunteers opted for cognitive engagement when confronted with a low-intensity photograph, and most chose to distract themselves from a high-intensity one, suggesting that switching strategies is a normal, healthy way of dealing with negativity in life. The researchers also gave the volunteers a "surprise" memory test at the end of the experiment and found—as expected—that memory for the emotional photographs was impaired whenever volunteers opted for distraction and disengagement. This result suggests that distraction, as a strategy for emotional regulation, works by not allowing the emotional information to enter memory at all.

This Won't Hurt a Bit

Intense images are powerful stimuli for priming negative emotions, but even so the scientists wanted a test that was closer to real-life events. In another experiment, they used the anticipation of electrical shocks to create a measurable state of anxiety for volunteers. They hooked them up to electrodes, with which they administered 20 shocks of varying intensity. Just prior to each shock, the volunteers viewed a brief written description of the intensity level of the upcoming shock, allowing them time—12 seconds on average—to choose and use a strategy for regulating their anxiety before getting zapped. As before, the volunteers spoke out loud about which cognitive strategy they chose. The scientists crunched together the data on shock intensity and cognitive choices, and the results were essentially the same as before. As reported in the online edition of *Psychological Science* in September, volunteers were much more likely to opt for a reappraisal strategy ("this one won't be so bad") when confronting an unpleasant but tolerable shock, and they were much more likely to try distracting themselves when they anticipated a strong and intensely painful shock. In short, people generally have the cognitive flexibility to adapt their regulatory choices for the situation at hand.

The finding that people naturally choose to engage with only mildly unpleasant emotions is not surprising. Reinterpretation of emotional events has long been known to be an effective coping strategy, and it is often taught as a part of cognitive-behavior therapy. The findings on distraction, however, run contrary to a long-held view that it is important to engage with intense emotional challenges—and that avoiding or "repressing" them is harmful. This interpretation has been steadily losing ground. Evidence is mounting that, under extremely adverse conditions, some emotional disengagement may indeed be tonic. This approach appears to be true for disaster victims; for people with severe, ruminating depression; and of course, for alcoholics in early recovery. M

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

WRAY HERBERT is writer in residence at the Association for Psychological Science.

(Further Reading)

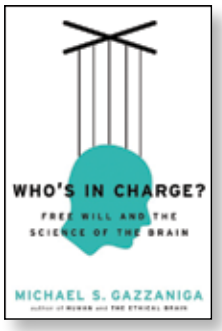
◆ **Emotion-Regulation Choice.** Gal Sheppes, Susanne Scheibe, Gaurav Suri and James J. Gross in *Psychological Science.* Published online September 29, 2011.

books

RESPONSIBLE RELATIONSHIPS

Who's in Charge? Free Will and the Science of the Brain

by Michael S. Gazzaniga. Ecco (HarperCollins Publishers), 2011 ($27.99)



Most people are convinced that they possess a central "me," a purposeful self who calls all the shots. In the past few decades, however, this view has come under attack, as scientists and philosophers increasingly adopt a mechanistic view of the universe, in which physical laws govern our every move and choice. Know enough about how the brain operates, and you will be able to understand—and predict—the mind.

Into the fray enters neuroscientist Michael S. Gazzaniga, who dodges those well-worn reductionist arguments to offer a fresh perspective in his new book. Determinism has no meaning in the context of free will, he argues, because personal responsibility is a contract between two people, not a property of the brain.

Gazzaniga begins his exploration of free will by describing how no single entity or process generates our conscious experience; rather it is assembled on the fly. Yet we still feel like we live a narrative of our own choosing, a result of what he dubs the "interpreter" module of the brain. This specialized neural system integrates our actions, memories and perceptions, stitching together a unified story.

Flaws in this well-orchestrated system can be observed in people with brain damage. Gazzaniga introduces a patient who cannot see objects from the right side of his brain but can draw them. Another individual reports that her hand belongs to her son. These and other cases expose consciousness for what it really is: a vast assembly of disparate systems that interact to form our experiences.

Still, simply tallying up all our neurons' behavior will not help us make sense of our lives. Just as knowing every detail about all cars on the highway will never predict traffic, tracking every neural twitch will never reveal a specific mental state. Furthermore, the brain makes decisions within a social context, not in isolation. Here Gazzaniga gets to the real question about free will: personal responsibility. He points out that notions of accountability arise only when brains interact, which neuroscience is barely beginning to understand.

Gazzaniga concludes by urging us to consider this bigger social picture when debating what it means to be a responsible agent. An accessible read, *Who's in Charge?* will make you think twice about your actions and interactions. —*Lena Groeger*

EXTREME SELF-HELP

The Journal of Best Practices: A Memoir of Marriage, Asperger Syndrome, and One Man's Quest to Be a Better Husband

by David Finch. Scribner, 2012 ($25)

Asperger syndrome is not funny—or at least it is not supposed to be. People with the disorder, which falls on the autism spectrum, lack social intuition and may fixate on obscure topics. For many, the condition can be isolating. Yet in *The Journal of Best Practices,* David Finch finds hilarity in the disorder, all the better for his fellow Aspies, the self-anointed nickname for members of the Asperger community, and the rest of us, who gain an entertaining lesson on what their lives can be like.

Finch is 30 years old when he is diagnosed with the syndrome. Although his wife, Kristen, accepts Finch as is, for him the diagnosis is both a revelation and a road map to mending their marriage, a union he believes had unraveled because of his Aspie quirks.

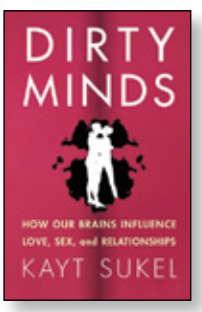
Finch tries to overcome those tendencies—his self-involvement, obsessions, inflexibility and lack of empathy—by developing a guide to help him become if not "neurotypical," at least easier to live with. A behavioral instruction manual appeals to Finch, who thrives on order. One of his many epiphanies comes after a workplace performance review, when he goes home and declares to Kristen that he wants one from her, too.

That may sound like a strategy sure to backfire, but Finch's efforts to understand when to use his "best practices" and when to just be himself is part of how he learns to manage Asperger syndrome. Empathy remains Finch's Holy Grail, and his struggle to master it is an ongoing source of frustration for him.

Despite this lack of social intelligence, Finch understands how funny his earnest attempts at empathy come off to neurotypicals. He puts his Aspie obsessiveness to admirable use, diving into reality television, couples massages and *Cosmopolitan* magazine to try to "get" his wife. He studies—and parrots—talk-show hosts to learn how to converse, and he adopts a persona to suit every occasion: Business Man for the office and Outgoing Man for social encounters.

That Finch ultimately discards these amazing compensatory skills is a testament to the happy medium he discovers. Forget a scarlet A for Asperger. Finch has earned an A for effort, and he should wear it proudly. —*Jordan Lite*

LABOR OF LOVE



Dirty Minds: How Our Brains Influence Love, Sex, and Relationships

by Kayt Sukel. Free Press, 2012 ($25)

Consider this ubiquitous yet poorly understood affliction: love. It is likely to cause drastic changes in behavior, difficulty concentrating and rapid mood swings. Even after it ends, the sufferer gains no respite. Instead more erratic behavior emerges, and the afflicted often report a loss of appetite, crying and obsessive thoughts. Yet we all want it.

In *Dirty Minds,* journalist Kayt Sukel takes on this nearly universal brain scrambler. She tackles provocative questions to determine why love can relieve us of our sanity, why we seem to pick the wrong people, and why the turmoil of a relationship can induce feelings resembling both love and hate. She sprinkles in personal anecdotes from her recent divorce, her trials on the dating scene and advice from her friends.

On her investigative journey to uncover the truth about the brain in love, Sukel also interviews scientists and combs through the literature. A highlight of the book comes when Sukel bravely agrees to

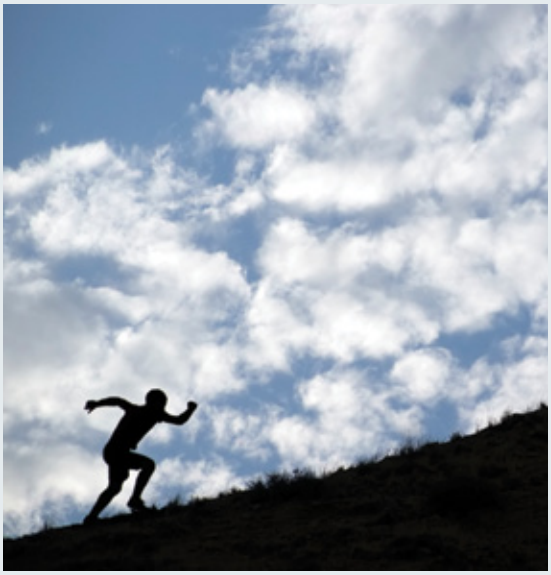
Roundup: **Strengthen Your Resolve**

Three books suggest ways to improve your life.

We typically spend four hours every day resisting temptation, says social psychologist Roy F. Baumeister. In **Willpower: Rediscovering the Greatest Human Strength** (Penguin Press, 2011), Baumeister and *New York Times* science writer John Tierney reveal that one of our most valued abilities—self-control—actually operates like a muscle: it can be strengthened with practice and exhausted by overuse. The authors share how entrepreneurs, parents and artists have improved their willpower and how we can, too.

Improved self-control can help diminish stress, an important skill for harried parents. In **Kids Pick Up on Everything: How Parental Stress Is Toxic to Kids** (CreateSpace, 2011), family coach David Code describes how, just as they can catch a cold, children can "catch" their parents' anxiety, making them more likely to develop learning disabilities, mental illness and obesity. Code, who founded the Center for Staying Married and Raising Great Kids, tells parents to relax and have fun to help their children grow up healthier and happier.

Another key to a good life comes from our ability to explore complex social problems through stories, writes Jonathan Gottschall in **The Storytelling Animal: How Stories Make Us Human** (Houghton Mifflin Harcourt, 2012). Gottschall, who studies the link between literature and science, argues that our penchant for spinning yarns developed, as with other behaviors, to enhance our survival. This book may offer insight on how our storytelling abilities can help us solve problems. *—Victoria Stern*



ISTOCKPHOTO

participate in a study that requires her to bring herself to orgasm in the claustrophobic confines of a functional MRI machine while researchers look on.

Dirty Minds is not short on moments of insight, such as when Sukel discovers that an orgasm involves as many as 30 different areas of the brain. She learns that cheating likely has a genetic link, which lends some credence to her married friend's idea that his biology requires him to take lovers. Moreover, she finds that many of the same parts in the brain become active when people feel both love and hate, a confusing phenomenon she admits she got to know well during the dissolution of her marriage.

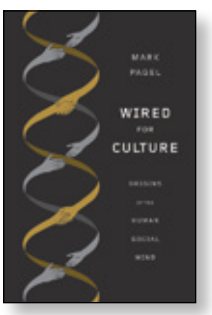
Sukel, however, is quick to caution that although today's studies on the subject of love may indeed explain a thing or two about one's patterns in relationships, they cannot serve as an instruction manual any more than DNA discoveries can predict the diseases you will contract. In other words, when it comes to love, much of the mystery remains. That, Sukel says, is just the way she likes it, even if it means her newly single future will involve plenty of awkward dates and false starts.

A fun and insightful read, *Dirty Minds* manages to evoke the feel of both a wine-laden conversation with an old friend and a great neuroscience lecture from your favorite college professor. *—Samantha Murphy*

ARE YOU COPYING ME?

Wired for Culture: Origins of the Human Social Mind

by Mark Pagel. W. W. Norton, 2012 ($29.95)



Human populations have faced bottlenecks over time that put them in peril. Evolutionary biologist Mark Pagel believes that humans overcame these forces by banding together in larger groups, which may have propelled their brain capacity to greater heights.

In *Wired for Culture,* Pagel proposes that humans learn best through imitation. Aggregating into larger clusters allowed social learning to truly flourish, ultimately leading to the formation of societies, technology and culture. Humans are unique among other primates, however, in that they did more than simply pick up the latest spear technology by observing and mimicking their peers. As they developed more complex communication skills, they were able to adapt and pass on these tactics to the next generation. Pagel theorizes that the evolution of language ratcheted up the exchange of the ideas and skills that eventually formed the basis of different cultures.

Yet this collaborative spirit did not extend to make humans altruistic, Pagel concludes. As a species, we join forces only with those whom we trust and whose actions we anticipate will be similar to our own. In fact, he proposes that thousands of different languages exist in the world because we are inclined to promote trust within our own social circles but confusion among outsiders. Language allowed us to pass along individual cultures as much as it segregated, and even protected, us from different ones.

The book's narrative is diffuse, veering offtrack as Pagel attempts to explain lofty concepts. Also problematic is that Pagel appears to build his theory on the absence of contradictory evidence—our brain and behavior differ from those of other primates, so the human mind must help explain these distinctions. He cites theories from philosophers and evolutionary biologist Richard Dawkins, who argues that people who are genetically related are more likely to behave altruistically toward one another.

Despite these issues, the main themes are worth exploring. If Pagel's theory is correct, the success of the human race largely depended on culture, which spawned not just from neural connections within the brain but also from the social connections people made within their communities. *—Brian Mossop*

ask the Brains

Is it possible to use more of our brain?

—***Michael Lenneville***, *Washington, D.C.*

Barry Gordon, *professor of neurology and cognitive science at the Johns Hopkins University School of Medicine, replies:*

YES! THOUGH perhaps not how you might imagine. You can't put more of your brain to work. Your whole brain is working all the time, even when you think you're just being lazy. What you can do is make it work more productively.

There are two proved strategies to make your neural systems more efficient. The first strategy is to focus, which is hard to do. It is quite difficult to force your brain to stay on task and to shut off extraneous thoughts. Yet by concentrating, your brain can muster the neural tools it needs to tackle a complex problem. In fact, intense focus may be one reason why so-called savants become so extraordinary at performing extensive calculations or remembering a slew of facts.

The second approach is optimization. The human brain is far from an ideal "thinking machine." Our mental processes are slow, and the accuracy of our memory is far from perfect. Our intrinsic limitations are compounded by the simple mental blunders we make; these unhelpful tendencies, however, are correctable. For instance, you can become a better problem solver by looking beyond your personal biases and blind spots to consider alternative solutions. The more you learn to recognize and seek a variety of answers, the better your brain will be at finding optimal solutions.

Some proof that focus and optimization can improve the brain's performance comes from research on video gamers. Neuroscientists at the University of Rochester have shown that even novice gamers

It is quite difficult to force your brain to stay on task and to shut off extraneous thoughts.

can improve cognitive skills such as perception and attention by playing action video games. These games can strengthen players' mental acuity because they require intense concentration and ruthless self-correction (otherwise, your friends shoot you!).

Sometimes, however, you may think better when you're not trying so hard. (You have to consider all the alternatives.) Periods of artistic and scientific creativity—when people often tackle the biggest, most open-ended problems—usually require letting your brain meander, percolate, chill. It may not feel like you are using more of your brain when you unleash it in this way, but one virtue of the human brain is that it often does its best work when it does not seem to be working at all.

What are the structural differences in the brain between animals that are self-aware (humans, apes) and other vertebrates?

—***Emma Schachner***, *Salt Lake City*

Robert O. Duncan, *a behavioral scientist at York College, the City University of New York, responds:*

SELF-AWARENESS DISTINGUISHES humans from most other species. In psychology, self-awareness is defined as metacognition, awareness of one's own ability to think. In humans, metacognition and other advanced cognitive skills, such as social intelligence, planning and reasoning, are all thought to depend on a region of the brain called the prefrontal cortex.

If we assume that the prefrontal cortex permits metacognition, then the answer is simple: species that fail to demonstrate metacognition tend to lack brain areas that resemble the prefrontal cortex. But because this area serves many cognitive functions and is well connected to the rest of the brain, the region is probably not the sole locus of metacognition. In other words, the prefrontal cortex may be necessary but not sufficient for self-awareness. Some psychologists speculate that self-awareness may arise in animals with greater overall cognitive ability, larger brain size or a higher degree of connectivity among brain areas.

Identifying the precise structural differences that make some creatures self-aware and others not is quite challenging. Most important, it is difficult to pinpoint and compare subtle structural differences across species in the face of more dramatic differences in brain morphology. For example, dolphins and chimpanzees both demonstrate metacognition, but their brains look completely different.

Additionally, simply identifying which species exhibit self-aware behavior has proved tricky because no reliable behavioral tests for the trait exist. In 1970 Gordon G. Gallup, Jr., of the University at Albany, S.U.N.Y., developed the "mirror test" to assess metacognition in chimpanzees. A chimp passes the test if it uses the mirror to inspect a mark that has been painted on its face. Although the majority of chimps pass, some do fail, causing certain scientists to consider the test unreliable.

The difficulties we have assessing self-awareness demonstrate that it is a complex trait and support the idea that no single brain area is dedicated to it. Overall, the prefrontal cortex may be critical for metacognition, but self-awareness most likely emerges when this region is highly interconnected with the rest of the brain. M

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

JAMIE CARROLL *iStockphoto*

Head Games

Match wits with the Mensa puzzlers

1 REDEFINED

Fill in each blank with a word that fits the definitions to its right and left.

Peeved	_____	**Intersect**
Tip	_____	**Thesis**
Type or sort	_____	**Benevolent**
Flag	_____	**Wheel**
Hang	_____	**Straight stick**
Gang	_____	**Box**

2 TGIF

Go from WORK to PLAY in six steps, changing one letter at a time and making a valid English word at each step.

WORK

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

PLAY

3 CONFOUNDING COMPOUNDING

Find one word that can be added to the beginning of each of the words below to make four new words.

_____ **real**

_____ **slip**

_____ **arm**

_____ **burn**

4 MATHLETICS

What number, squared, plus 13, is equal to one quarter of one third of twice 174?

5 PRECOCITY

When Molly's teacher asked her how old she was, she said, "In 18 years, I'll be nine times as old as I was six years ago." How old is Molly?

6 HIDDEN PATTERN

What number should come next in the following series? Pick the best choice from the answers shown.

2 16 54 128 250 ?

a) 360 b) 432 c) 500 d) 512

7 BARGAIN BLING

If a watch costs $20, a necklace costs $25 and a ring costs $15, how much will a bracelet cost?

8 CANDY CONUNDRUM

The youngsters had 32 cents between them. For this amount, they could get four gum balls and eight chocolate bars or 10 gum balls and four chocolate bars. How much did each chocolate bar and each gum ball cost?

9 WORD SQUARE

Fill in the following word square so that it reads the same across and down and contains a total of three Es, two each of S, L, O, G, R and A, and one T.

O	**G**	**R**	**E**
G			
R			
E			

10 MYSTERY MULTIPLICANDS

The following multiplication problem contains one each of the numbers from one to nine. Some of them are given to help you get started. Fill in the rest to make the equation correct.

4 _ 3
× 1 _
5 _ _ 6

Answers

1. Cross, Point, Kind, Tire, Post, Pack.
2. WORK, PORK, PERK, PEAK, PEAT, PLAT, PLAY.
(There may be other ways.)
3. Side.
4. Four.
5. Nine.
6. b) 432, which is twice 216, the cube of 6.
The numbers are double the cubes of 1, 2, 3, 4 and 5.
7. $25. The jeweler charges $5 per consonant.
8. Gum balls cost two cents, and chocolate bars cost three cents.
9.

O	**G**	**R**	**E**
G	**O**	**A**	**L**
R	**A**	**T**	**S**
E	**L**	**S**	**E**

10. 483 × 12 = 5,796.

SCIENTIFIC AMERICAN™ Travel

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Face the challenges posed by conservation planning and wildfire management, guided by Dr. Yohay Carmel. Dive into discoveries in astro-particle physics with Dr. David Lunney. Glimpse the neuroscience behind sensory perception and visual illusions with Dr. Stephen Macnik and Dr. Susana Martinez-Conde. Focus on developments in the nature and maintenance of memory with Dr. Jeanette Norden. Take in evolving thought on humankind's emigration from Africa with Professor Chris Stringer.

Discover the possibilities in environmental and neuroscience, particle physics, and anthropology. Visit archaeological sites and imagine the finds to come. Soak in the Mediterranean lifestyle. Savor the cuisine of Genoa. If you're game for field trips, we've designed behind-the-scenes experiences to extend your fun, from the European Organization for Nuclear Research, known as CERN, in Geneva to fascinating Herodium in Palestine. Send your questions to concierge@insightcruises.com or call 650-787-5665. Please join us!

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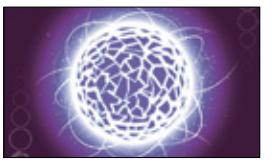


NUCLEAR ASTROPHYSICS

Speaker: David Lunney, Ph.D.

A Hitchhiker's Guide to the Universe

An introduction to the formation and composition of the visible universe, emphasizing the synthesis of Earth's chemical elements in the stars. Discover the key reactions, the evolutionary process of nuclear systems, and the forces that shape ongoing debates in nuclear astrophysics.

Nuclear Cooking Class

Get cooking with a discussion of the physics behind element formation by fusion and capture reactions. Dr. Lunney will highlight the need to weigh ingredient atoms to precisely determine mass. Take a seat in a precise corner of the physics kitchen and feast on the latest on nucleosynthesis.

Weighing Single Atoms

The most precise balance known to man is an electromagnetic trap in which ionized atoms are made to dance, revealing their mass. We'll look at the basics of atomic mass measurement. Learn about current techniques of mass measurement, how these methods compare, and the diverse programs worldwide that use them. Glimpse the shape of the future of precision measurement.

Panning the Seafloor for Plutonium: Attack of the Deathstar

Long, long ago, not so far away, did an exploding supernova bathe our planet with its stellar innards? Explore the research, theories, and phenomena that suggest the role of a local supernova in the creation of the sun and its planetary system.

NEUROSCIENCE MEMORY

Speaker: Jeanette Norden, Ph.D.

How the Brain Works

Get the lay of the land in this introductory neuroscience session showing how the brain is divided into functional systems. A special emphasis will be on limbic and reticular systems, which underlie learning and memory, executive function, arousal, attention, and consciousness.

Memory and All That Jazz

Memory is among the most precious of human abilities. Find out what neuroscience has revealed about how we learn and remember. Pinpoint how different areas of the brain encode different types of information—from the phone number we need to remember for only a moment to the childhood memories we retain for a lifetime.

Losing your Memory

When we lose our memories, we lose a critical part of ourselves and our lives. Dr. Norden will introduce the many clinical conditions that can affect different types of learning and memory.

Use it or Lose it!

While memory can be lost under a wide variety of clinical conditions, most memory loss during aging is not due to strokes or neurodegenerative disease, but to lifestyle. Building evidence suggests that aging need not lead to significant memory loss. Find out how to keep your brain healthy as you age.

COGNITIVE NEUROSCIENCE

Speakers: Stephen Macknik, Ph.D. and Susana Martinez-Conde, Ph.D.

How the Brain Constructs the World We See

All understanding of life experiences is derived from brain processes, not necessarily the result of actual events. Neuroscientists are researching the cerebral processes underlying perception to understand our experience of the universe. Discover how the brain constructs, not reconstructs, the world we see.

Cognitive Neuroscience, cont.

Windows on the Mind

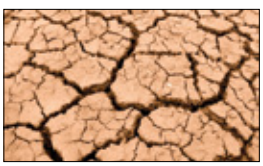
What's the connection behind eye movements and subliminal thought? Join Dr. Macknik and Dr. Martinez-Conde in a look at the latest neurobiology behind microsaccades, the involuntary eye movements that relate to perception and cognition. Learn how microsaccades suggest bias toward certain objects, their relationship to visual illusions, and the pressing questions spurring visual neurophysiologists onward.

Champions of Illusion

The study of visual illusions is critical to understanding the basic mechanisms of sensory perception and advancing cures for visual and neurological diseases. Connoisseurs of illusion, Dr. Macknik and Dr. Martinez-Conde produce the annual Best Illusion of the Year Contest. Study the most exciting novel illusions with them and learn what makes these brain tricks work.

Sleights of Mind

Magic fools us because humans have hardwired processes of attention and awareness that can be "hacked." A good magician employs the mind's own intrinsic properties. Magicians' insights, gained over centuries of informal experimentation, have led to new discoveries in the cognitive sciences, and reveal how our brains work in everyday situations. Get a front-row seat as the key connections between magic and the mind are unveiled!



CLIMATOLOGY

Speaker: Yohay Carmel, Ph.D.

Prioritizing Land for Nature Conservation: Theory and Practice

Forest clearing, climate change, and urban sprawl are transforming our planet at an accelerating rate. Conservation planning prescribes principles and practical solutions for selecting land for protection, assigning land for development, and minimizing the negative impact on nature. Taking a bird's-eye view of approaches to conservation, we'll put the hot topics and tough questions in perspective through an insightful discussion.

Facing a New Mega-Fire Reality

Worldwide, the area, number, and intensity of wildland fires has grown significantly in the past decade. Fire-protection strategies used in the past may not work in the future. Learn the roots and causes of wildfires and recent efforts to predict, manage, and mitigate fire risk. Gain food for thought about the complex interface between science and policy.

HUMAN EVOLUTION

Speaker: Chris Stringer, Ph.D.

Human Evolution: the Big Picture

Time-travel through 6 million years of human evolution, from the divergence from African apes to the emergence of humans. In 1871, Charles Darwin suggested that human evolution had begun in Africa. Learn how Darwin's ideas stand up to the latest discoveries, putting his tenets into context and perspective.

The First Humans

About 2 million years ago the first humans appeared in Africa, distinctly different from their more ancient African ancestors. Discover what drove their evolution and led to a spread from their evolutionary homeland to Asia and Europe. Explore current thinking on the early stages of human evolution.

The Neanderthals: Another Kind of Human

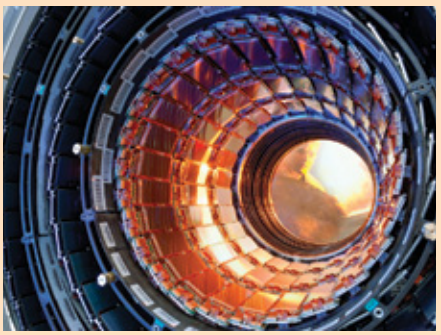
Our close relatives, the Neanderthals, evolved in parallel with *Homo sapiens.* Often depicted as bestial ape-men, in reality they walked upright as well as we do, and their brains were as large as ours. So how much like us were they? What was their fate? Track the evolution of the Neanderthals in light of the latest discoveries.

The Rise of *Homo Sapiens*

Modern humans are characterized by large brains and creativity. How did our species arise and spread across the world? How did we interact with other human species? We will examine theories about modern human origins, including Recent African Origin ("Out of Africa"), Assimilation, and Multiregional Evolution, and delve in to the origins of human behavioral traits.

SCIENTIFIC AMERICAN Travel HIGHLIGHTS

INSIDER'S TOUR OF CERN



Pre-cruise: October 22, 2012—From the tiniest constituents of matter to the immensity of the cosmos, discover the wonders of science and technology at CERN. Join Bright Horizons for a private full-day tour of this iconic nuclear-research facility.

Whether you lean toward concept or application, there's much to pique your curiosity. Discover the excitement of fundamental research and get an insider's look at the world's largest particle physics laboratory.

Our full-day tour will be led by a CERN physicist. We'll have an orientation, visit an accelerator and experiment, get a sense of the mechanics of the Large Hadron Collider (LHC), make a refueling stop for lunch, and have time to peruse exhibits and media on the history of CERN and the nature of its work.

This tour includes: Bus transfer from Geneva, Switzerland to our Genoa, Italy hotel (October 23) • 3 nights' hotel (October 20, 21, 22) • 3 full breakfasts (October 21, 22, 23) • Transfers to and from the hotel on tour day (October 22) • Lunch at CERN • Cocktail party following our CERN visit • Do-as-you-please day in Geneva, including transfers to and from downtown (October 21) • Transfer from airport to our Geneva hotel

The price is $899 per person (based on double occupancy). This trip is limited to 50 people. NOTE: CERN charges no entrance fee to visitors.

EPHESUS

November 1, 2012—Many civilizations have left their mark at Ephesus. It's a complex and many-splendored history, often oversimplified. Bright Horizons pulls together three important aspects of understanding Ephesus that are rarely presented together. You'll meander the Marble Road, visit the legendary latrines, check out the Library, and visit the political and commercial centers of the city. A visit to the Terrace Houses will enhance your picture of Roman-era Ephesus.

We'll take a break for Mediterranean cuisine in the Selcuk countryside, then visit the Ephesus Museum in Selcuk, where city excavation finds are showcased, and you'll get a fuller look at local history, from the Lydians to the Byzantines.

ATHENS

November 1, 2012—The Parthenon and its Acropolis setting are stunning, no doubt about it. Requiring no interpretation, they are ideal for a DIY Athens excursion. On the other hand, visiting the new Acropolis Museum and the National Archaeological Museum with a skilled guide who's on your wavelength adds immeasurably to the experience. We suggest you join Bright Horizons on a focused trip. You'll see the Parthenon frieze, exquisite sanctuary relics, and Archaic sculpture at the Acropolis Museum (as you can see from the picture, the museum sits just below the Acropolis).

Lunch is tucked away at a taverna favored by Athenian families. For dessert, we'll visit the richest array of Greek antiquities anywhere—at the National Archaeological Museum.

the cranial network

BY DWAYNE GODWIN AND JORGE CHAM

SOME SCIENTISTS THINK THE NEED TO SOCIALIZE DROVE OUR BRAINS TO EVOLVE A BIG CORTEX WITH LOTS OF CONNECTIONS...

IN FACT, A RECENT STUDY EVEN LINKS THE NUMBER OF FACEBOOK FRIENDS WITH HAVING LARGER GRAY MATTER.

of "Friends"

THE BRAIN HAS OVER 100 BILLION NEURONS.

IF ALL OF THEM WERE CONNECTED TO EACH OTHER, THERE WOULDN'T BE ENOUGH ROOM IN YOUR SKULL.

NEURONS FORM A TYPE OF SOCIAL NETWORK IN YOUR BRAIN.

SOME PARTS ARE MORE HIGHLY CONNECTED THAN OTHERS.

CONNECTING THE NEURONS IN SMART WAYS ALLOWS THE BRAIN TO PROCESS AND SHARE INFORMATION MORE EFFICIENTLY.

IT'S THE DYNAMICS OF THESE CONNECTIONS THAT MAKE THE BRAIN SO WELL "LIKED."

BRAIN FEED Update Status · Most Recent

What's on your mind?

Prefrontal Cortex: Ok, let's get things done!
9 milliseconds ago from Your Brain · Comment · Like

View all 5 comments:

Inferior Frontal Gyrus: I'm speechless.
1 millisecond ago

The Amygdala: :(
2 milliseconds ago

Hypothalamus: ROTFL!!!!!!
3 milliseconds ago

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

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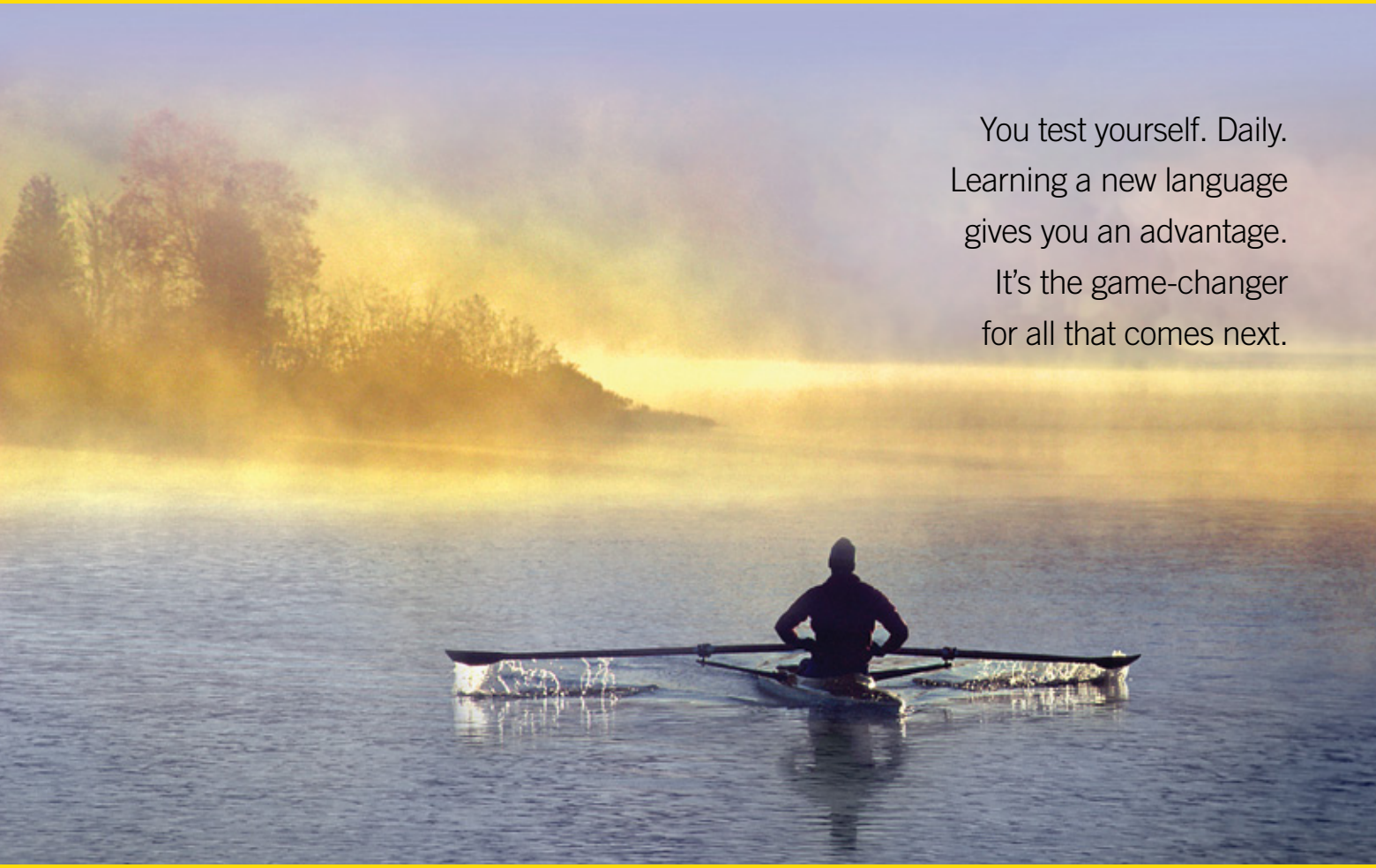

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