During the July 4th weekend of 1994, while riding in a 1988 Chevy Blazer with his wife at the wheel, a computer engineer named Jeff Bezos laid the groundwork for a retail revolution. Back then, the Internet was an insider’s tool, largely limited to government and academic circles. But after months of careful observation of its usage, Bezos envisioned a dramatic expansion of this network, one that would bring it into the daily lives of ordinary people. In the car, he sketched out a business plan for a project that would realize his vision: the Internet, he understood, could boost the efficiency of mail-order businesses, starting with books.

In a risky move, Bezos and his wife, Mackenzie, left lucrative jobs in New York’s financial sector to build an Internet-based bookseller based in Seattle. They called it “Amazon,” after the interminable South American river and its many branches. After a few months of testing and without any advertising, the company started racking up

Scientists have mapped the innovative mind so that we can remake our own in its image

By Evangelia G. Chrysikou
Illustration by MCKIBILLO
$20,000 weekly in sales. In just a few years Amazon was worth billions. Bezos forever changed how people purchase goods and made a lasting impact on the business world.

For entrepreneurs worldwide, Amazon.com is a model of innovation. Yet creativity can come in many forms. Consider Procter & Gamble’s line of Swiffer products: a reconceptualization of mops, sweepers and dusters based on the simple insight that cleaning with disposable parts makes the job easier and more fun. Designer Gianfranco Zaccai of Herman Miller and his team are credited with inventing Swiffer, which reaps more than $500 million in annual sales.

Innovation matters in an enormous variety of professions. It elevates the careers of chefs, university presidents, psychotherapists, police detectives, journalists, teachers, engineers, architects, attorneys and surgeons, among other professionals. The contributions of creative thought can directly translate into career advancement as well as financial rewards. In an unfavorable economic climate, raising your creative game may even mark the difference between survival and failure.

Psychologists broadly define creativity as the purposeful generation and implementation of a novel idea. In the workplace, it may be more aptly characterized as the effortful pursuit and implementation of novelty that results in measurable useful outcomes. In numerous studies over the past few decades psychologists have tried to unravel the mysteries of exceptional creativity in the arts or sciences, considering the likes of Pablo Picasso, Mozart, Virginia Woolf, the Wright brothers and Albert Einstein. These investigations, along with others into the origins of everyday problem solving, have uncovered genetic, social and economic factors (as well as lucky circumstances) that contribute to creative thought.

Although creativity has long been considered a gift of a select minority, psychologists are now revealing its seeds in mental processes such as decision making, language and memory that all of us possess. Thus, we can all boost our creative potential. Recent studies show promise for techniques that break down people’s established ways of viewing the world as well as strategies that encourage unconscious thought processes. Read on to try these at home—or at work.

An Open Mind

Iconic individuals such as Bezos, the late Steve Jobs, Martha Stewart, Steve Ells (founder of the successful Chipotle Mexican Grill restaurants) and many others have inspired entrepreneurs and professionals to hone their creative skills. Individuals and companies have typically used creativity workshops, brainstorming sessions, self-help books, training videos and even hypnosis as vehicles for such improvement. Whether such practices influence the likelihood of creative leaps is unknown. Yet psychologists and neuroscientists have made some important discoveries that can help us understand the states of mind that benefit creative thought.

When people consider creativity, they generally think of the birth of novel ideas. Idea generation is indeed the first important stage of the creative process. To come up with new ideas for achieving a goal, you need, roughly speaking, an open mind—that is, one guided by minimal rules and constraints. In 2009 neuroscientist Sharon Thompson-Schill of the University of Wisconsin-Madison and her team reported that an open mind may encourage more novel ideas compared with a closed mind.
of Pennsylvania and her colleagues proposed that creative inspiration might benefit from a state of lower cognitive control—that is, fewer restrictions on your thoughts and behavior.

Your more prosaic, rule-guided thought is associated with a burst of activity in your prefrontal cortex, a region on the surface of the brain behind your forehead that regulates your decisions, thoughts and actions. When you abandon rules or blur your attentional focus, this region quiets down. Thompson-Schill’s team called this latter state hypofrontality and hypothesized that it holds various benefits for language learning and creative thought, among other aspects of cognition.

Researchers found early hints of hypofrontality in the mid-1990s, when they measured the electrical activity in the brains of people who were generating new ideas. By picking up electrical waves on the scalp, scientists can get a sense of a person’s “brain state,” say, awake or asleep, focused or relaxed. When someone is engaged in a task that requires cognitive control and focused attention—for instance, solving a math problem or deciding what to pack for a camping trip—so-called beta waves, which oscillate at a frequency of 15 to 20 hertz, usually dominate. When people came up with new ideas, however, researchers recorded alpha waves over the prefrontal cortex. These eight- to 12-hertz waves are typically a sign of relaxed wakefulness and diffuse attention. Their presence thus bolstered the notion that idea generation is associated with a state of lower cognitive control.

The behavior of patients whose frontal lobes have partially degenerated as a result of frontotemporal dementia or similar disorders is consistent with this view. These individuals show severe impairments in regulating their thoughts and actions but may experience spontaneous musical or artistic creativity they lacked before they got sick. [For more on the link between creative thinking and unconventional behavior, see “The Unleashed Mind,” by Shelley Carson; SCIENTIFIC AMERICAN MIND, May/June 2011.]

More recent data strengthen the case for the importance of hypofrontality in everyday creativity. In a study published in 2011 Thompson-Schill and I showed participants pictures of ordinary objects (tissues, for example) and asked them to tell us either a common use (wiping your nose) or an uncommon application (protective stuffing for a package) for each one. Participants who came up with unusual uses for the items showed minimal activity in prefrontal brain regions and heightened activity in posterior brain regions that are typically in charge of visuospatial skills. In contrast, those who thought of typical uses showed the reverse pattern. Thus, generating novel applications for objects also seems to benefit from less filtering of knowledge and experiences, which enables people to consider a greater variety of possible answers. What is more, innovative ideas can arise from paying attention to the visual properties of things, such as their shape, size and material makeup. Instead of highlighting previous knowledge, the brain enters a state that emphasizes often overlooked perceptual elements.

Scientists have been able to mimic this brain state by applying electrical stimulation to the scalp and thereby improving problem-solving ability. These data lend considerable credence to the idea that diminished activity in the prefrontal cortex, particularly on the left side of the brain, underlies an important part of the creative process [see “Tickling the Brain,” on page 29].
Thought Control

In addition to idea generation, true creativity involves evaluating your options, picking the best one and implementing a plan for realizing your vision. This evaluation process, the second critical stage of creative thought, involves a mental state in which the cognitive filter in the prefrontal cortex is on instead of off. In a study published in 2011 psychologist Kalina Christoff of the University of British Columbia and her colleagues asked college students from the Emily Carr University of Art + Design in Vancouver to generate illustrations for book covers on a special drawing tablet while inside a brain scanner. The students were asked to come up with ideas for their sketches for 30 seconds and then spend 20 seconds evaluating what they had sketched. The researchers found that the prefrontal cortex among other regions were more active during the evaluation stage, suggesting that the executive control network that filters data and exerts brakes on behavior is more engaged during the evaluative phase of the creative process.

Creative individuals may thus be those who are better able to upregulate or downregulate their cognitive-control system depending on the demands of the situation—a skill known as cognitive flexibility. In a 2010 study Darya Zabelina and Michael Robinson, both then at North Dakota State University, first assessed the creativity of 50 undergraduate students using standard paper-and-pencil tests and then measured their capacity for cognitive control with the Stroop task. In this task, people see a list of color words (“yellow,” “blue,” “red,” and so on) that are typed in a color that often does not match the word. The goal is to state the color of the word regardless of what the word says. This task measures how well a person can filter out irrelevant information to focus on what is important, a major feature of cognitive control. Although creative and noncreative subjects performed equally well on this task overall, creative subjects did better every time they had to switch from a matching combination (for instance, the word “red” appearing in red type) to a clashing one (“red” showing up in blue letters). These results indicate that creative people show greater cognitive flexibility, which can support the ability to both generate novel ideas and put these ideas into action.

Psychologists have been exploring ways to expand our creativity, enhancing the arsenal of techniques that promote idea generation and implementation. Some of these methods appear in the sections that follow.

Mental Push-ups

Exercises that shake up people’s typical ways of thinking can help put them in a creative mind-set. A version of the alternative-uses task described earlier, for example, can get people to rethink the way they categorize objects. In a study published in 2006 my colleagues and I asked college students to devise up to six alternative uses for 12 common objects in 15 minutes. Then we asked them to solve practical problems, such as affixing a candle upright on a wall using a book of matches and a box of tacks. (Hint: think of the box as a platform.) For some of the students, the objects in the first task were related to the practical problems; for others, they were not. These two groups did equally well on the practical problems, however, and both solved significantly more of them than did students who had not completed the alternative-uses task. Thus, the training task seemed to benefit our subjects more generally, putting them in the right state of mind for creative problem solving.

Another method for boosting creativity might be to describe objects in unusual ways—for example, in terms of their

If you are struggling with a difficult project at work, take a break. The recess may shake loose some creative thoughts, especially if you choose to do something dramatically different from what your job entails.
ANNE-LOUISE QUARFOTH

features rather than their function. In a 2012 study psychologist Tony McCaffrey of the University of Massachusetts Amherst trained students to define objects generically by their shape, size and materials. A candle might be described as wax and wick or, even more obscurely, as string and cylindrically shaped lipids. McCaffrey encouraged the students to ask themselves, “Can I break the description down any further?” and “Does my description imply a particular use?” Participants who received this training showed a 67 percent boost in problem-solving performance relative to those who did not. One reason for their advantage: they were more likely to notice obscure features of the problems that were necessary for their solution.

Performing common tasks in an unconventional order can also upset your ordinary thought processes and thereby raise your creative prospects. In a 2012 study psychologist Simone Ritter of Radboud University Nijmegen and her colleagues asked a group of students to prepare a breakfast sandwich with butter and chocolate (a popular combination in the Netherlands). Half of them made the sandwich the regular way, and the rest were prompted to do so following an unusual sequence of steps. All the students were then given two minutes to generate uses for a brick and another two minutes to come up with as many answers as they could to the question “What makes sound?” Those who made the sandwich in an unconventional way—an activity that violated their expectations, the researchers theorized—came up with more different types of answers and thus scored higher on cognitive flexibility.

If mental exercises are not giving you enough good ideas, try enlisting your unconscious. One trick for achieving this mental power shift is to sleep on the problem. In particular, the stage of sleep known as rapid eye movement or dream sleep can help establish associations between remote ideas. These links may bring out solutions to conundrums that stumped you just before dozing off

---E.G.C.

Tickling the Brain

Neuroscientists have been able to tweak the creative process by enhancing or suppressing activity in frontal brain regions. In a technique called transcranial direct-current stimulation, minute amounts of electric current flow through a pair of electrodes affixed to the scalp and thereby either raise or lower activity in the underlying brain regions. In a study published in 2011 neuroscientist Allan Snyder of the Center for the Mind in Sydney and his colleagues used this method to affect the ability of individuals to solve arithmetic puzzles involving matchsticks (see illustration at right). The initial problems could all be solved using a similar strategy, but the last two required abandoning what had worked before and developing a novel approach. Snyder’s team hypothesized that the right hemisphere enhances creativity, whereas the left hemisphere impedes it. Indeed, when the researchers depressed activity in the left frontal cortex while exciting the right frontal cortex in some of their subjects, these individuals solved the last two problems at higher rates than those who received the opposite pattern of stimulation (left excitation, right inhibition) or sham stimulation.

Beyond fostering alternative problem-solving strategies, this neurostimulation technique can also support the generation of novel ideas, such as findings new uses for objects. In a study earlier this year my colleagues and I inhibited neural activity in the left prefrontal cortex of participants while they came up with a common or an uncommon use for objects presented to them in pictures. These individuals thought of significantly more uncommon uses— and did so about a second faster—than people who received inhibitory current over their right prefrontal cortex or those who were given sham stimulation. These results strongly support the hypothesis that blocking cognitive filtering by inhibiting the left prefrontal cortex during idea generation can promote creative thought.

—E.G.C.

People who made a sandwich in an unconventional way came up with more varied answers to open-ended questions.

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Similar benefits can come from letting your mind wander or deliberately distracting yourself. In a 2006 study psychologist Ap Dijksterhuis, also at Radboud University, and his colleagues asked people to generate novel names for products. Those who were sidetracked by a different task thought of more original names than those who worked on the problem continuously. In later studies, Dijksterhuis’s team demonstrated that unconscious processing could yield answers to very difficult problems that require an extensive search of stored knowledge. These results suggest that if you are stuck on a difficult problem, it pays to take a break and do something else. [For more on the benefits of daydreaming, see “Living in a Dream World,” by Josie Glausiusz, Scientific American Mind, March/April 2011.]

What you do during your break turns out to be important, too. In a 2009 study psychologist Sophie Ellwood of the Center for the Mind in Sydney and her colleagues asked participants to think of as many uses as they could for a piece of paper. Some performed the task continuously for four minutes; others paused after two minutes and did a similar exercise (thinking of synonyms for words) for five minutes before getting back to the paper task. A third group used the break to complete a personality questionnaire. The people who took a break generated more uses for the paper than those who were not interrupted, but those who did the unrelated activity performed the best on this creative task.

Keeping Your Distance

Many other social and emotional factors can spur creative thought. One of them is thinking of a problem as physically far away. Psychologist Lile Jia of Indiana University Bloomington and his colleagues gave students practical problems similar to the one involving a candle discussed earlier. They told some participants that their responses would be collected for scientists at a university a few thousand miles away and others that a research team at their own university would get the results. Remarkably, the students who thought they were solving the problems for the faraway inves-

### Aim to Innovate

**Try these tips to maximize your creativity at work.**

- **Become an expert.** A solid knowledge base will allow you to connect remote ideas and see their relevance to a problem.
- **Observe.** When trying to come up with a new product or service, carefully study how people use what is currently available and what problems they face.
- **Know your audience.** Walk in the shoes of the intended consumer. How would a child use a remote control? How would an elderly person access a voting booth? How can I make this dessert for a vegan?
- **Step out of your comfort zone.** Seek activities outside your field of expertise. Take a class; read a book; travel to a foreign country. New experiences often bring forth novel thoughts.
- **Be willing to work alone.** Group brainstorming can help you synthesize your ideas, but it is far more effective if you have started the creative process on your own.
- **Talk to outsiders about your work.** A novel perspective can help you see alternative solutions or possible faults with your original idea.
- **Have fun.** A good mood can forge remote associations. Upbeat music may help but also makes tasks that demand focus more difficult. If you need to concentrate, dampen your demeanor with sad songs.
- **Take a nap or let your mind wander.** Sleep and daydreaming can enlist your unconscious mind to work on a problem that is stumping you.
- **Take a break.** Occupying your mind with a different task can unleash novel solutions.
- **Challenge yourself.** Disrupt your daily routine. Abandon your initial idea (even if it works) and look for a new one. Borrow from other people’s answers and try to improve on them.

Dreams,” by Dierdre Barrett; Scientific American Mind, November/December 2011].

Those who saw themselves in the distant future solved more problems than those who simply imagined the following day.
tigation solved twice as many problems as the other students. The researchers hypothesized that the psychological distance caused the students to approach the problems in more abstract terms, thereby facilitating their solution.

Distancing yourself in time can also promote innovation. Psychologist Nira Liberman of Tel Aviv University and her colleagues asked participants to imagine themselves either one day or one year in the future. Then the researchers gave their subjects a series of problems to solve and asked them to imagine themselves working on them on that future day. Those who pictured themselves in the distant future solved significantly more problems than those who simply imagined the following day.

Beyond psychological distance, physical distance from others can also increase creative output. Despite its presumed benefits, group brainstorming is beneficial only after you have come up with a few solutions for a complex problem on your own, recent research suggests. In addition, brainstorming works better in the context of casual, brief semistructured social interactions such as a lunch or social gathering than in long, organized meetings. Interactions among people with varied backgrounds—say, those who have different but related fields or those who work at other places—is especially good at promoting the synthesis and development of new ideas.

But no matter how imaginative our thoughts, we still must cross one major hurdle: our fear of risk. People tend toward safe routes, yet safety is not conducive to radical new solutions. Bezos and his wife not only had to come up with the notion of Amazon. They also had to be willing to cast off their current careers to pursue an uncertain future. Amid the financial and other practical and professional constraints of most workplaces, not to speak of other life concerns, abandoning a satisfactory but safe solution to pursue a new concept may be the biggest challenge to capitalizing on creative potential. As Bezos once said, “Innovation is disruption.”

(Further Reading)