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COVER STORY

The science behind creativity

Psychologists and neuroscientists are exploring where creativity comes from and how to increase your own

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Paul Seli, PhD, is falling asleep. As he nods off, a sleep-tracking glove called Dormio, developed by scientists at the Massachusetts Institute of Technology, detects his nascent sleep state and jars him awake. Pulled back from the brink, he jots down the artistic ideas that came to him during those semilucid moments.

Seli is an assistant professor of psychology and neuroscience at the Duke Institute for Brain Sciences and also an artist. He uses Dormio to tap into the world of hypnagogia, the transitional state that exists at the boundary between wakefulness and sleep. In a mini-experiment, he created a series of paintings inspired by ideas plucked from his hypnagogic state and another series from ideas that came to him during waking hours. Then he asked friends to rate how creative the paintings were, without telling them which were which. They judged the hypnagogic paintings as significantly more creative. “In dream states, we seem to be able to link things together that we normally wouldn’t connect,” Seli said. “It’s like there’s an artist in my brain that I get to know through hypnagogia.”

The experiment is one of many novel—and, yes, creative—ways that psychologists are studying the science of creativity. At an individual level, creativity can lead to personal fulfillment and positive academic and professional outcomes, and even be therapeutic. People take pleasure in creative thoughts, research suggests—even if they don’t think of themselves as especially creative. Beyond those individual benefits, creativity is an endeavor with implications for society, said Jonathan Schooler, PhD, a professor of psychological and brain sciences at the University of California, Santa Barbara. “Creativity is at the core of innovation. We rely on innovation for advancing humanity, as well as for pleasure and entertainment,” he said. “Creativity underlies so much of what humans value.”

In 1950, J. P. Guilford, PhD, then president of APA, laid out his vision for the psychological study of creativity (*American Psychologist* (<https://psycnet.apa.org/record/1951-04354-001>), Vol. 5, No. 9, 1950). For half a century, researchers added to the scientific understanding of creativity incrementally, said John Kounios, PhD, an experimental psychologist who studies creativity and insight

at Drexel University in Philadelphia. Much of that research focused on the personality traits linked to creativity and the cognitive aspects of the creative process.

But in the 21st century, the field has blossomed thanks to new advances in neuroimaging. "It's become a tsunami of people studying creativity," Kounios said. Psychologists and neuroscientists are uncovering new details about what it means to be creative and how to nurture that skill. "Creativity is of incredible real-world value," Kounios said. "The ultimate goal is to figure out how to enhance it in a systematic way."

Speaking of Psychology

Creativity, insight and "eureka moments," with John Kounios, PhD

"Eureka moments" have led to some of humanity's greatest achievements in science, medicine, mathematics and the arts. But they're not always that dramatic -- we've nearly all had the experience o...



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Creativity in the brain

What, exactly, is creativity? The standard definition used by researchers characterizes creative ideas as those that are original and effective, as described by psychologist Mark A. Runco, PhD, director of creativity research and programming at Southern Oregon University ([Creativity Research Journal](https://doi.org/10.1080/10400419.2012.650092) (<https://doi.org/10.1080/10400419.2012.650092>), Vol. 24, No. 1, 2012). But effectiveness, also called utility, is a slippery concept. Is a poem useful? What makes a sculpture effective? "Most researchers use some form of this definition, but most of us are also dissatisfied with it," Kounios said.

Runco is working on an updated definition and has considered at least a dozen suggestions from colleagues for new components to consider. One frequently suggested feature is authenticity. "Creativity involves an honest expression," he said.

Meanwhile, scientists are also struggling with the best way to measure the

concept. As a marker of creativity, researchers often measure divergent thinking—the ability to generate a lot of possible solutions to a problem or question. The standard test of divergent thinking came from Guilford himself. Known as the alternate-uses test, the task asks participants to come up with novel uses for a common object such as a brick. But measures of divergent thinking haven't been found to correlate well with real-world creativity. Does coming up with new uses for a brick imply a person will be good at abstract art or composing music or devising new methods for studying the brain? "It strikes me as using way too broad a brush," Seli said. "I don't think we measure creativity in the standard way that people think about creativity. As researchers, we need to be very clear about what we mean."

One way to do that may be to move away from defining creativity based on a person's creative output and focus instead on what's going on in the brain, said Adam Green, PhD, a cognitive neuroscientist at Georgetown University and founder of the [Society for the Neuroscience of Creativity](https://www.tsfn.org/) (<https://www.tsfn.org/>). "The standard definition, that creativity is novel and useful, is a description of a product," he noted. "By looking inward, we can see the process in action and start to identify the characteristics of creative thought. Neuroimaging is helping to shift the focus from creative product to creative process."

That process seems to involve the coupling of disparate brain regions. Specifically, creativity often involves coordination between the cognitive control network, which is involved in executive functions such as planning and problem-solving, and the default mode network, which is most active during mind-wandering or daydreaming (Beaty, R. E., et al., *Cerebral Cortex* (<https://doi.org/10.1093/cercor/bhab100>), Vol. 31, No. 10, 2021). The cooperation of those networks may be a unique feature of creativity, Green said. "These two systems are usually antagonistic. They rarely work together, but creativity seems to be one instance where they do."

Green has also found evidence that an area called the frontopolar cortex, in the brain's frontal lobes, is associated with creative thinking. And stimulating the area seems to boost creative abilities. He and his colleagues used transcranial direct current stimulation (tDCS) to stimulate the frontopolar cortex of

participants as they tried to come up with novel analogies. Stimulating the area led participants to make analogies that were more semantically distant from one another—in other words, more creative (*Cerebral Cortex* (<https://doi.org/10.1093/cercor/bhw080>), Vol. 27, No. 4, 2017).

Green's work suggests that targeting specific areas in the brain, either with neuromodulation or cognitive interventions, could enhance creativity. Yet no one is suggesting that a single brain region, or even a single neural network, is responsible for creative thought. "Creativity is not one system but many different mechanisms that, under ideal circumstances, work together in a seamless way," Kounios said.

In search of the eureka moment

Creativity looks different from person to person. And even within one brain, there are different routes to a creative spark, Kounios explained. One involves what cognitive scientists call "System 1" (also called "Type 1") processes: quick, unconscious thoughts—aha moments—that burst into consciousness. A second route involves "System 2" processes: thinking that is slow, deliberate, and conscious. "Creativity can use one or the other or a combination of the two," he said. "You might use Type 1 thinking to generate ideas and Type 2 to critique and refine them."

Which pathway a person uses might depend, in part, on their expertise. Kounios and his colleagues used electroencephalography (EEG) to examine what was happening in jazz musicians' brains as they improvised on the piano. Then skilled jazz instructors rated those improvisations for creativity, and the researchers compared each musician's most creative compositions. They found that for highly experienced musicians, the mechanisms used to generate creative ideas were largely automatic and unconscious, and they came from the left posterior part of the brain. Less-experienced pianists drew on more analytical, deliberative brain processes in the right frontal region to devise creative melodies, as Kounios and colleagues described in a [special issue of *NeuroImage*](https://doi.org/10.1016/j.neuroimage.2020.116632) (<https://doi.org/10.1016/j.neuroimage.2020.116632>) on the neuroscience of creativity (Vol. 213, 2020). "It seems there are at least two pathways to get

from where you are to a creative idea," he said.

Coming up with an idea is only one part of the creative process. A painter needs to translate their vision to canvas. An inventor has to tinker with their concept to make a prototype that actually works. Still, the aha moment is an undeniably important component of the creative process. And science is beginning to illuminate those "lightbulb moments."

Kounios examined the relationship between creative insight and the brain's reward system by asking participants to solve anagrams in the lab. In people who were highly sensitive to rewards, a creative insight led to a burst of brain activity in the orbitofrontal cortex, the area of the brain that responds to basic pleasures like delicious food or addictive drugs (*NeuroImage* (<https://doi.org/10.1016/j.neuroimage.2020.116757>), Vol. 214, 2020). That neural reward may explain, from an evolutionary standpoint, why humans seem driven to create, he said. "We seem wired to take pleasure in creative thoughts. There are neural rewards for thinking in a creative fashion, and that may be adaptive for our species."

The rush you get from an aha moment might also signal that you're onto something good, Schooler said. He and his colleagues studied these flashes of insight among creative writers and physicists. They surveyed the participants daily for two weeks, asking them to note their creative ideas and when they occurred. Participants reported that about a fifth of the most important ideas of the day happened when they were mind-wandering and not working on a task at hand (*Psychological Science* (<https://doi.org/10.1177/0956797618820626>), Vol. 30, No. 3, 2019). "These solutions were more likely to be associated with an aha moment and often overcoming an impasse of some sort," Schooler said.

Six months later, the participants revisited those ideas and rated them for creative importance. This time, they rated their previous ideas as creative, but less important than they'd initially thought. That suggests that the spark of a eureka moment may not be a reliable clue that an idea has legs. "It seems like the aha experience may be a visceral marker of an important idea. But the aha experience can also inflate the meaningfulness of an idea that doesn't have

merit,” Schooler said. “We have to be careful of false ahas.”

Boosting your creativity

Much of the research in this realm has focused on creativity as a trait. Indeed, some people are naturally more creative than others. Creative individuals are more likely than others to possess the personality trait of openness. “Across different age groups, the best predictor of creativity is openness to new experiences,” said Anna Abraham, PhD, the E. Paul Torrance Professor and director of the Torrance Center for Creativity and Talent Development at the University of Georgia. “Creative people have the kind of curiosity that draws them toward learning new things and experiencing the world in new ways,” she said.

We can’t all be Thomas Edison or Maya Angelou. But creativity is also a state, and anyone can push themselves to be more creative. “Creativity is human capacity, and there’s always room for growth,” Runco said. A tolerant environment is often a necessary ingredient, he added. “Tolerant societies allow individuals to express themselves and explore new things. And as a parent or a teacher, you can model that creativity is valued and be open-minded when your child gives an answer you didn’t expect.”

One way to let your own creativity flow may be by tapping into your untethered mind. Seli is attempting to do so through his studies on hypnagogia. After pilot testing the idea on himself, he’s now working on a study that uses the sleep-tracking glove to explore creativity in a group of Duke undergrads. “In dream states, there seems to be connectivity between disparate ideas. You tend to link things together you normally wouldn’t, and this should lead to novel outcomes,” he said. “Neurally speaking, the idea is to increase connectivity between different areas of the brain.”

You don't have to be asleep to forge those creative connections. Mind-wandering can also let the ideas flow. "Letting yourself daydream with a purpose, on a regular basis, might allow brain networks that don't usually cooperate to literally form stronger connections," Green said.

However, not all types of daydreams will get you there. Schooler found that people who engage in more personally meaningful daydreams (such as fantasizing about a future vacation or career change) report greater artistic achievement and more daily inspiration. People who are prone to fantastical daydreaming (such as inventing alternate realities or imaginary worlds) produced higher-quality creative writing in the lab and reported more daily creative behavior. But daydreams devoted to planning or problem-solving were not associated with creative behaviors (*Psychology of Aesthetics, Creativity, and the Arts* (<https://doi.org/10.1037/aca0000342>), Vol. 15, No. 4, 2021).

It's not just what you think about when you daydream, but where you are when you do it. Some research suggests spending time in nature can enhance creativity. That may be because of the natural world's ability to restore attention, or perhaps it's due to the tendency to let your mind wander when you're in the great outdoors (Williams, K. J. H., et al., *Journal of Environmental Psychology* (<https://doi.org/10.1016/j.jenvp.2018.08.005>), Vol. 59, 2018). "A lot of creative figures go on walks in big, expansive environments. In a large space, your perceptual attention expands and your scope of thought also expands," Kounios said. "That's why working in a cubicle is bad for creativity. But working near a window can help."

Wherever you choose to do it, fostering creativity requires time and effort. "People want the booster shot for creativity. But creativity isn't something that comes magically. It's a skill, and as with any new skill, the more you practice, the better you get," Abraham said. In a not-yet-published study, she found three factors predicted peak originality in teenagers: openness to experience, intelligence, and, importantly, time spent engaged in creative hobbies. That is, taking the time to work on creative pursuits makes a difference. And the same is true for adults, she said. "Carve out time for yourself, figure out the conditions that are conducive to your creativity, and recognize that you need to keep

pushing yourself. You won't get to where you want to go if you don't try."

Those efforts can benefit your own sense of creative fulfillment and perhaps lead to rewards on an even grander scale. "I think everyday creativity is the most important kind," Runco said. "If we can support the creativity of each and every individual, we'll change the world."

How to become more creative

1. Put in the work: People often think of creativity as a bolt of inspiration, like a lightbulb clicking on. But being creative in a particular domain—whether in the arts, in your work, or in your day-to-day life—is a skill. Carve out time to learn and practice.

2. Let your mind wander: Experts recommend "daydreaming with purpose." Make opportunities to let your daydreams flow, while gently nudging them toward the creative challenge at hand. Some research suggests meditation may help people develop the habit of purposeful daydreaming.

3. Practice remote associations: Brainstorm ideas, jotting down whatever thoughts or notions come to you, no matter how wild. You can always edit later.

4. Go outside: Spending time in nature and wide-open spaces can expand your attention, enhance beneficial mind-wandering, and boost creativity.

5. Revisit your creative ideas: Aha moments can give you a high—but that rush might make you overestimate the merit of a creative idea. Don't be afraid to revisit ideas to critique and tweak them later.

Video: <https://player.vimeo.com/video/905362500?>

dnt=1&badge=0&autoplay=0&player_id=0&app_id=58479

Further reading

[Creativity: An introduction \(https://www.cambridge.org/highereducation/books/creativity/1001805B2BF695B5A0508A187D125757#overview\)](https://www.cambridge.org/highereducation/books/creativity/1001805B2BF695B5A0508A187D125757#overview)

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[The eureka factor: Aha moments, creative insight, and the brain \(https://psycnet.apa.org/record/2015-24774-000\)](https://psycnet.apa.org/record/2015-24774-000)

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[Creativity anxiety: Evidence for anxiety that is specific to creative thinking, from STEM to the arts \(https://doi.org/10.1037/xge0000630\)](https://doi.org/10.1037/xge0000630)

Daker, R. J., et al., *Journal of Experimental Psychology: General*, 2020

[Predictors of creativity in young people: Using frequentist and Bayesian approaches in estimating the importance of individual and contextual factors \(https://doi.org/10.1037/aca0000322\)](https://doi.org/10.1037/aca0000322)

Asquith, S. L., et al., *Psychology of Aesthetics, Creativity, and the Arts*, 2020

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