SCIENCE AND CULTURE

Computers take art in new directions, challenging the meaning of "creativity"

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In an experiment carried out in early 2017, researchers from Rutgers University, Facebook, and the College of Charleston in South Carolina asked 18 volunteers to look at hundreds of images and rate them on characteristics such as "novelty," "complexity," and "structure." Some of the images showed paintings created by human artists. The rest had been generated by new artificial intelligence (AI) algorithms, trained on more than 80,000 paintings from the past few hundred years, that had been developed to generate new visuals in a variety of styles.

The experiment's participants, recruited from Amazon's Mechanical Turk crowdsourced worker program, were also asked to decide if each artwork on the screen had been created by a human or a computer. That classification task suggests a sort of artistic Turing test for creativity. Namely, can an algorithm autonomously generate art that is indistinguishable from art made by people? And if so, does that mean the computer is "creative"—actually producing something new rather than merely emulating human artists?

Digital artist Paul Brown's prints include *Reconfigurable Painting* (*Left*), a work that has been reconfigured on occasion by the artist and even visitors; *Wrapping Paper* (*Center*), an unfinished work that explores different color combinations by using a single tile; and *Long Loop* (*Right*), which shows precompiled graphic sprites that were played back like a multipage flip-book, under the control of the generative program. Image credit: Paul Brown and Kevin Allen (photographer).

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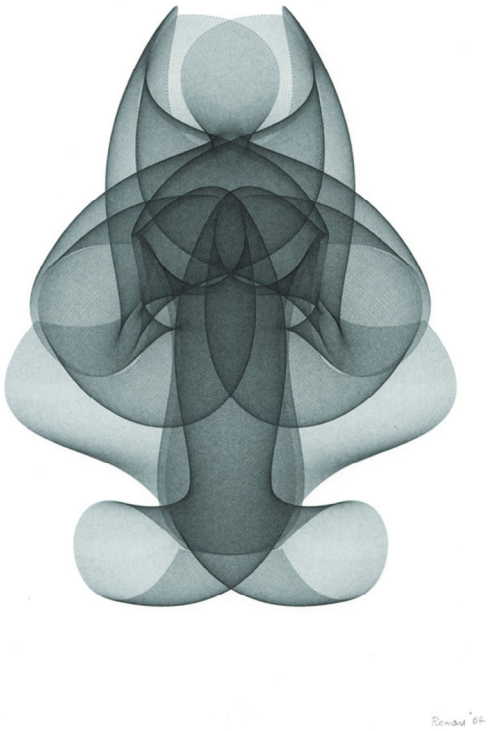

In the spring 2002, artist Roman Verostko saw the *Black Madonna* (*Left*), a famous 12th-century sculpture at the Abbey of Montserrat in Spain. Later that year, Verostko began writing code and using a pen-and-ink plotter to create his own version of the work (*Right*). Image credit: *Left*: Shutterstock.com/Valery Bareta. *Right*: Roman Verostko (artist).

The researchers hypothesized that the participants would rank human-made art higher than machine-made in every category. They were wrong. In June 2017, at the Eighth International Conference on Computational Creativity in Atlanta, the researchers reported that, on average, participants rated computer-generated artworks as being more novel, complex, and surprising than the paintings made by people (1). The art generated by the algorithm was attributed more often to people than to computers.

The authors of the study didn't test for statistical significance and acknowledged that the meaning of these rankings is debatable. Even so, they concluded that "the fact that subjects found the images generated by the machine intentional, visually structured, communicative, and inspiring, with similar levels to actual human art, indicates that subjects see these images as art." Although some would disregard the notion of computers as creative, the peculiar inner workings of deep learning raise the possibility that the coders or artists aren't directly responsible for the form their creation takes.

It's a controversial stance. "Creativity for a long time was considered to be something that made us unique, almost like humans had a monopoly over creativity," says computer scientist Maya Ackerman at Santa Clara University in California. "Humans have a strong bias against thinking about computers as being creative." Critics offer a succinct rejoinder to arguments suggesting computers are themselves capable of creativity: Algorithms are programmed by people, so whatever the machine produces ultimately leads back to the coder. No one's dismissing the powerful technology that computers bring to the field, but many reject the notion that they're forging a new branch of art.

Computers are, though, making some types of art more accessible. "One of the beauties of using a computer is that more people can get involved and produce artworks that would have been impossible to produce before," says artist Paul Brown, a pioneer in digital art.

Artists have been exploring ways to use computers for decades, but in recent years the lines between programmers and artists have grown blurry. Many artists now learn to code; computer scientists develop algorithms with aesthetics as the goal. Projects such as Deep Dream, a program that uses neural networks to produce new visuals, let anyone use AI approaches to generate, ostensibly, art. In a 2016 charity auction in

San Francisco, prints made by using Deep Dream sold for as high as $8,000, raising questions about whether the uploader or the algorithms should get credit.

One of the reasons behind the question is that even as computer scientists find new ways to use neural networks, they often don't exactly understand why these algorithms are so successful at pattern recognition and other tasks. That lack of knowledge extends to programmers who develop algorithms such as Deep Dream that infuse art with AI. The process is neither entirely random nor entirely intentional.

But that may be beside the point, says Ackerman. The creativity of computers doesn't have to be understood or even regarded in the same way people usually think about art. Computer programs "ultimately give more power to the human, and in the end it's the human who pulls it all together."

The Art Machine

Starting in the mid-1960s, a handful of engineers and computer scientists began writing computer code to generate images. In August 1968, London's Institute for Contemporary Art (ICA) hosted *Cybernetic Serendipity,* a groundbreaking exhibition that included images, films, music, and sculpture demonstrating that computers could be used for artistic expression. Sixty thousand people attended the exhibition, which ran for 10 weeks.

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>
> —Maya Ackerman

"It was the first time that the ICA experienced people queuing to get into an exhibit," recalled the exhibit's curator, British art critic Jasia Reichardt, at a March 2018 event commemorating the 50th anniversary of *Cybernetic Serendipity* in Washington, DC. The "serendipity" in the title, she says, spoke to the randomness that underlies computer-generated art.

What hasn't changed in the last half-century, she says, is that artists are using computers as tools. What has changed is the attitude of artists. "Then, to use a computer was an adventure," she says. "Today, it is a necessity."

In an essay published in 1967 in *Art Forum,* artist Sol LeWitt (2) described an emerging new approach to art, known as conceptualism: "When an artist uses a conceptual form of art, it means that all the planning and decisions are made beforehand and the execution is a perfunctory affair," he wrote. "The idea becomes the machine that makes the art."

Although he wasn't using the word "machine" in a literal sense, LeWitt nevertheless captured the essence of computer-generated art, says Brown, who launched his career after visiting *Cybernetic Serendipity*. The idea is encoded in the algorithm; the computer becomes the machine that makes the art. The human is a few steps removed from whatever emerges from that idea.

Before the computer age, Brown says, art was off limits to people who lacked certain skills, such as drawing. Brown himself says he nearly abandoned his own artistic ambitions after an early mentor, upon seeing one of Brown's drawings, told him he'd never be an artist. But computers led him to a successful career and an influential portfolio, which was on display in the spring and summer of 2018 at the National Academy of Sciences in Washington, DC, in an exhibition called *Process, Chance, and Serendipity: Art That Makes Itself.*

Computational Creativity?

Brown wasn't the only one exploring the role of computers in creative artistic work. In the early 1970s, British artist Harold Cohen developed AARON, a computer program that generated art according to a few rules. To draw a human figure, for example, AARON used a list of body parts together with basic information about how they attached to a central torso. The program drew with an automated drawing device and could mix paint and clean brushes. Over the next four decades, AARON's drawings, mostly depicting living things, progressed from what looked like the creation of a young child to more sophisticated paintings. AARON inspired other artists. Minneapolis-based artist Roman Verostko, a pioneer in algorithmic art, began writing code to create art in the 1960s. "I wanted to teach my machine how to draw the way I draw, and to generate forms," he says. In Cohen's work, he says he saw a kindred spirit. "I was amazed at how his work evolved," Verostko says. "His work gave me confidence and inspired me to stay with it."

Early projects such as AARON laid the groundwork for a field called "computational creativity," which has bloomed into a robust discipline in recent years. Its practitioners use computer tools to probe the idea of creativity—for example, designing neural networks that can be trained on existing images to create new ones. The goal is to build systems that are as creative as humans and to be able to analyze the creative process as an algorithm. "Over the past several decades, we've been working on giving computers creativity, meaning that if a human did what the computer system was doing, then it would have been considered creative," explains Ackerman.

Artist Assistants

Newer computer-powered tools may not only generate art but also enhance the artist's skills. Three years ago, Ackerman introduced a computer program called ALYSIA, or Automated LYrical Songwrlting Application. ALYSIA uses data analysis to write songs, including both melody and lyrics. The program is built on machine-learning algorithms, which "learn" through exposure to large existing datasets.

Ackerman's program, which she released as a smartphone app in January, trained on thousands of sounds and melodies to learn the basic structure of melody, harmony, and chords. The program generates lyrics and melodies based on its prior knowledge of what songs sound like; the user decides which ones

to use and pieces them together. A user can also specify certain instruments or ask ALYSIA to input a lyric and then receive a tune to accompany it. (Ackerman says she created it after being frustrated by her own inability to compose music she actually wanted to hear.)

The idea is not, Ackerman says, to replace human songwriters. ALYSIA is a tool that can inspire a songwriter and do the work of a collaborator. "It essentially helps a human explore the creative space," she says. She estimates that a thousand people have used the experimental version of ALYSIA, and one user, a man who had never played a musical instrument, wrote an aria for an opera, in Italian. "The computer has a meaningful role," she says. "It does something that I'm no good at."

Studio artist and computer scientist Jennifer Jacobs, who in July 2019 will launch a new Human Computer Interaction research lab at the University of California, Santa Barbara, has designed a software tool called "Dynamic Brushes" that combines programming and digital drawing. Its features include a drawing editor for making art and a programming environment for writing code.

Creating that software, she says, involved "a kind of negotiation between different forms of expression, in trying to reconcile the types of things you can do with code and the type of things you can do by hand." Some of the artists she enlisted to test her software were reluctant at first about learning programming. "While they were aware and excited about using tools like Processing or code, they were hesitant because they recognized they would lose the manual tools they were invested in," Jacobs says. Using their feedback, she was able to develop Dynamic Brushes as a programming environment for artists who traditionally work by hand. An artist draws on a tablet computer, for example, and uses the programming language to create computer operations that automatically transform or respond to elements of the hand-drawn artwork (3).

Tools of the Trade

History is replete with examples of how new technologies have facilitated new sorts of creative approaches—computers are only the latest example, says Brown. Michelangelo, after all, was one of the most talented stonemasons of his time, showing what was possible with sculpture. In the 19th century, American portrait painters invented the paint tube, which gave painters more flexibility in the colors they used and where they painted. Reichardt says artists use computers today the way they used pencils 100 years ago. "To make a sketch, to try something out, to make a discovery." She says the 1968 show was a revelation of these powerful new tools.

Ackerman hopes that as the field advances, artists and nonartists alike warm to the idea that a computer can, in some sense, be creative. That idea has already come a long way. Cohen, for example, "didn't like attributing creativity to a system," she says. "He said they could only make art in very specific styles that their creators understood very well" (4). But new tools have pushed artists well past that point, says Reichardt. "Machine learning allows us today to let the computer be better than us," she says. "It lets you move beyond your ability."

1 Elgammal A, et al. (2017) CAN: Creative adversarial networks generating "art" by learning about styles and deviating from style norms. *Proceedings of the Eighth International Conference on Computational Creativity*, eds Goel A, Jordanous A, Pease A (Association for Computational Creativity, Atlanta), pp 96–103.

2 LeWitt S (1967) Paragraphs on conceptual art. *Art Forum* 5:79–84.

3 Jacobs J, et al. (2018) *Dynamic Brushes: Extending Manual Drawing Practices with Artist-Centric Programming Tools*, Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (Association for Computing Machinery, New York). Available at https://dl.acm.org/citation.cfm?id=3170427.3186492. Accessed January 17, 2019.

4 Cohen H (2010) Driving the creative machine. Talk given at Orcas Center, WA, Crossroads Lecture Series. Available at www.aaronshome.com/aaron/publications/orcastalk2s.pdf. Accessed September 15, 2018.