# Order in Pollock's Chaos

*Computer analysis is helping to explain the appeal of Jackson Pollock's paintings. The artist's famous drips and swirls create fractal patterns, similar to those formed in nature by trees, clouds and coastlines*

By Richard P. Taylor

In a drunken, suicidal state on a stormy March night, Jackson Pollock (1912–1956) laid down the foundations of his masterpiece *Blue Poles: Number 11, 1952*. He unrolled a large canvas across the floor of his windswept barn and, using a wooden stick, dripped the canvas with household paint from an old can.

This was not the first time the artist had dripped a painting onto canvas. In contrast to the broken lines painted by conventional brush contact, Pollock had developed a technique in which he poured a constant stream of paint onto horizontal canvases to produce uniquely continuous trajectories. This deceptively simple act polarized opinion in the art world. Was this primitive painting style driven by raw genius, or was he simply a drunk who mocked artistic traditions?

I had always been intrigued by Pollock's work because, in addition to my life as a physicist, I painted abstract art. Then, in 1994, I decided to put my scientific career on hold and to paint full-time. I left the physics department of the University of New South Wales and headed off to the Manchester School of Art in England, which had a reputation for a "sink or swim" approach to painting. In the bleak month of February, the school packed us students off to the Yorkshire moors in the north of England, telling us that we had one week to paint what we saw. But a violent snowstorm made the task impossible, so I sat down with a few friends, and we came up with the idea of making nature paint for us.

To do this, we assembled a huge structure out of tree branches blown down by the storm. One part of the structure acted like a giant sail, catching the motions of the wind swirling around it. This motion was then transferred to another part of the struc-

*BLUE POLES: NUMBER 11, 1952* exemplifies Pollock's trademark interweaving swirls of paint, which evolved through a series of depositions over the course of making a painting, a period of six months in the case of *Blue Poles*. (enamel and aluminum paint on canvas, 210 cm by 486.8 cm) ture that held paint containers, and these dripped a pattern corresponding to the wind's trajectory onto a canvas on the ground. As another large storm began to move through, we decided to retreat indoors, leaving the structure to paint through the night. The next day the storm had passed—and the image it left behind looked like a Pollock!

Suddenly, the secrets of Jackson Pollock seemed to fall into place for me: he must have adopted nature's rhythms when he painted. At this point, I realized I would have to head back into science to determine whether I could identify tangible traces of those rhythms in his artwork.

## Art Anticipates Science

DURING POLLOCK'S ERA, nature was assumed to be disordered, operating essentially randomly. Since that time, however, two fascinating areas of study have emerged to yield a greater understanding of nature's rules.

During the 1960s, scientists began to examine how natural systems, such as the weather, change with time. They found that these systems are not haphazard; instead, lurking underneath is a remarkably subtle form of order. They labeled this behavior "chaotic," and a new scientific field called chaos theory grew up to explain nature's dynamics. Then, in the 1970s, a new form of geometry emerged to describe the patterns that these chaotic processes left behind. Given the name "fractals" by their discoverer, Benoit Mandelbrot, the new forms looked nothing like traditional Euclidean shapes. In contrast to the smoothness of artificial lines, fractals consist of patterns that recur on finer and finer magnifications, building up shapes of immense complexity. The paintings created by our branch contraption suggested to me that the seemingly random swirls in Pollock's paintings might also possess some subtle order, that they might in fact be fractals.

A crucial feature in characterizing a fractal pattern is the fractal dimension, or *D*, which quantifies the scaling relation among the patterns observed at different magnifications. For Euclidean shapes, dimension is a simple concept described by the familiar integer values. For a smooth line (containing no fractal structure), *D* has a value of 1; for a completely filled area, its value is 2. For a fractal pattern, however, the repeating structure causes the line to occupy area. *D* then lies in the range between 1 and 2; as the complexity and richness of the repeating structure increase, its value moves closer to 2.

To figure out how all this might apply to Pollock's paintings, I went back to my lab at New South Wales, where I turned to the computer for help in quantifying the patterns on his canvases. It would have been impossible to perform this kind of analysis without the precision and computational power provided by such equipment. So I enlisted two colleagues who had special computer expertise—Adam Micolich, who was researching fractal analysis techniques for his doctorate in semiconductor devices, and David Jonas, an expert in image-processing techniques.

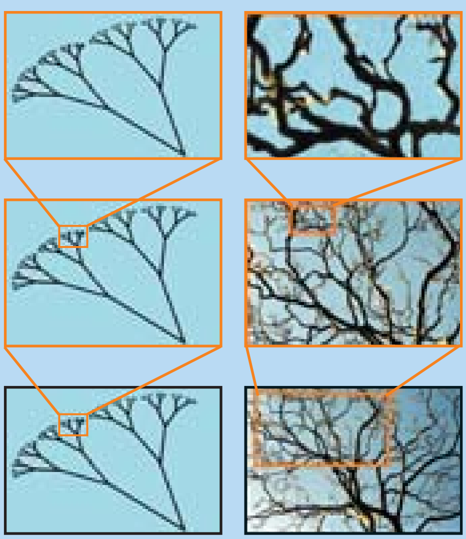
We started our investigation by scanning a Pollock painting into the computer [*see opposite page*]; we then covered it with a computer-generated mesh of identical squares. By analyzing which squares were occupied by the painted pattern and which were empty, we were able to calculate the statistical qualities of the pattern. And by reducing the square size, we were able to look at the pattern at what amounts to a finer magnification. Our analysis examined pattern sizes ranging from the smallest speck of paint up to approximately a meter. Amazingly, we found the patterns to be fractal. And they were fractal over the entire size range—the largest pattern more than 1,000 times as big as the smallest. Twenty-five years before their discovery in nature, Pollock was painting fractals.

## The Aesthetic Pull of Fractals

TAKING THIS SURPRISING finding a step further, I wondered whether the fractal nature of Pollock's paintings might contribute to their appeal. Only within the past decade have researchers begun to

## A Brief History of Fractals

- Fractal geometry developed from Benoit Mandelbrot's studies of complexity in the 1960s and 1970s. Mandelbrot coined the term "fractal" from the Latin *fractus* ("broken") to highlight the fragmented, irregular nature of these forms.
- Fractals display self-similarity—that is, they have a similar appearance at any magnification. A small part of the structure looks very much like the whole.
- Self-similarity comes in two flavors: exact and statistical. The artificial tree (*left series*) displays an exact repetition of patterns at different magnifications. For the real tree (*right*), the patterns don't repeat exactly; instead the statistical qualities of the patterns repeat. Most of nature's patterns obey statistical self-similarity, and so do Pollock's paintings.
- Fractals are characterized in terms of their "dimension," or complexity. The dimension is not an integer, such as the 1, 2 and 3 dimensions familiar from Euclidean geometry. Instead fractal dimensions are fractional; for example, a fractal line has a dimension between 1 and 2.



ARTIFICIAL TREE
Exact Self-Similarity

REAL TREE
Statistical Self-Similarity

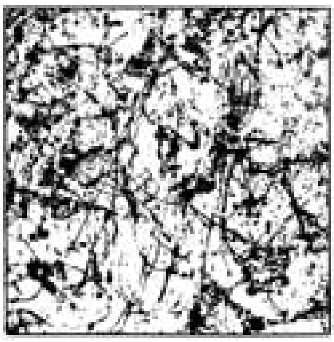
COURTESY OF RICHARD P. TAYLOR

# ANALYZING POLLOCK'S TECHNIQUE

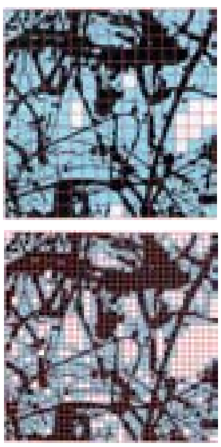
COMPUTER-ASSISTED ANALYSIS of Pollock's paintings reveals that the artist built up layers of paint in a carefully developed technique that created a dense web of fractals. Pollock was occasionally photographed while painting [*see illustration on page 121*], which gave me and my colleagues Adam Micolich and David Jonas more insight into his technique.

*Autumn Rhythm,* 1950, oil on canvas, 266.7 cm by 525.8 cm

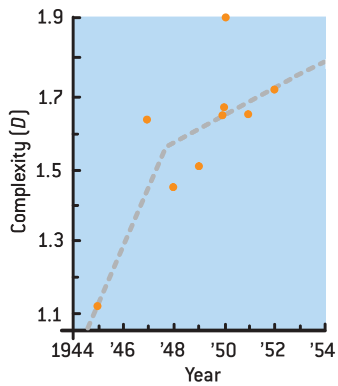
1 We began by scanning a painting into a computer. We could then separate the painting into its different colored patterns and analyze the fractal content of each pattern. We also looked at the cumulative pattern as the layers were added one by one to build the total picture. A detail from the black layer of *Autumn Rhythm* is shown at the right.



2 We covered the painting with a computer-generated mesh of identical squares. We then had the computer assess the statistical qualities of the pattern by analyzing which squares are occupied by the pattern (*blue*) and which are empty (*white*). Reducing the mesh size (*bottom*) is equivalent to looking at the statistical qualities of patterns at a finer magnification. We found the patterns to be fractal over the entire size range.



3 Studying the paintings chronologically showed that the complexity of the fractal patterns, *D,* increased as Pollock refined his technique. One *D* value is clearly an outlier—1.9 in 1950, a work that Pollock later destroyed (the analysis is based on a photograph). He may have thought this image was too dense or too complex and subsequently scaled back.





The evolution in *D* value had a profound effect on the appearance of the paintings. For fractals described by a low *D,* the repeating patterns build a smooth, sparse image. If the *D* value is closer to 2, however, the repeating patterns create a shape full of intricate, detailed structure.

WHAT EMERGES FROM BOTH the computer analysis and the examination of the photographs is evidence of a very systematic, deliberate painting process. Pollock started by painting small, localized "islands" of trajectories across the canvas. This is interesting because some of nature's patterns start with small nucleations that then spread and merge. He next painted longer, extended trajectories that linked the islands, gradually submerging them in a dense fractal web of paint. This stage of the painting formed an anchor layer: it actually guided the artist's subsequent painting actions. During the linking process, the painting's complexity (its *D* value) increased over a timescale of less than a minute. After this rapid activity, Pollock would take a break. He would then return to the canvas, and over a period lasting from two days to six months, he would deposit further layers of different-colored trajectories on top of the black anchor layer. Essentially, he was fine-tuning the complexity established by the anchor layer. Even when Pollock had finished painting, he took steps that maximized the fractal character, cropping to remove the outer regions where the fractal quality deteriorated. *—R.P.T.*

investigate visual preferences for fractal patterns. Using computer-generated fractals of various $D$ values, Clifford A. Pickover of the IBM Thomas J. Watson Research Center found that people expressed a preference for fractal patterns with a value of 1.8. Then, generating fractals by a different computer method, Deborah J. Aks and Julien C. Sprott of the University of Wisconsin–Madison came up with much lower preferred values of 1.3. Although the discrepancy might indicate that no $D$ value is preferred over any other—that instead the aesthetic quality of fractals depends on how the fractals are generated—I suspected the existence of a universally preferred value.

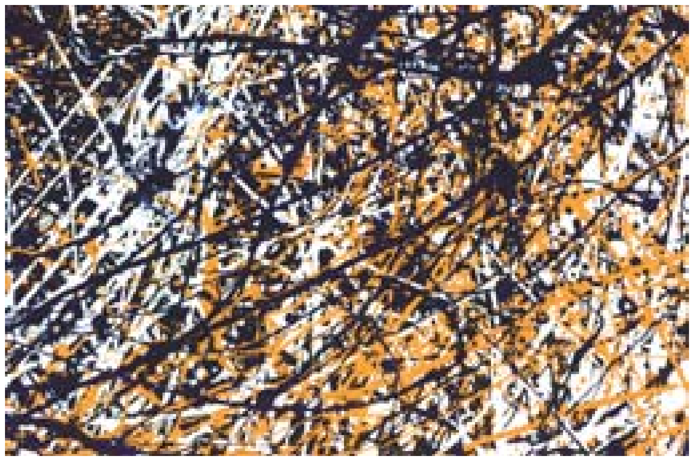
To see whether I was correct, I again sought assistance from experts—this time psychologists who study visual perception. Working with Branka Spehar of the University of New South Wales, Colin Clifford, now at the University of Sydney, and Ben Newell of University College London, I investigated three fundamental categories of fractals: natural (such as trees, mountains and clouds), mathematical (computer simulations) and human (cropped sections of Pollock's paintings). In visual perception tests, participants con-

## ALL DRIP PAINTINGS ARE NOT CREATED EQUAL

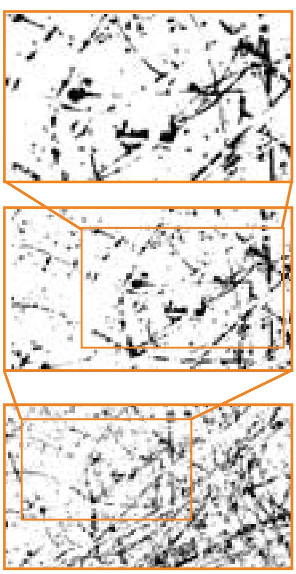
ARE FRACTALS an inevitable consequence of dripping paint? No. Consider the drip painting at the right, which is not a Pollock. Working with Ted P. Martin of the University of Oregon, I applied our computer analysis technique [*see box on preceding page*] to the image, examining its complexity at finer and finer magnifications. We found that the patterns at different magnifications were not described by the same statistics; in other words, they were not fractal. Indeed, when the painting was magnified, we could see that the dripped lines quickly ran out of structure (*left series below*). As a consequence, the pattern at high magnification looked very different from that at low magnification. A Pollock painting (*right series*), in contrast, displays the same general qualities when viewed at different magnifications, regardless of the location and sizes of the segments chosen. The same magnification sequence was used for both paintings.

Because the statistical qualities of fractals repeat at different magnifications, $D$ will not change over the various magnifications. It remains constant for the Pollock painting (*red in graph below*), whereas for the non-Pollock (*yellow*), it varies with pattern size, confirming that the painting is not fractal. My colleagues and I examine pattern sizes up to one meter but concentrate on sizes ranging from one to 10 millimeters, because we have found that this is the most sensitive region for distinguishing between a Pollock and a non-Pollock.

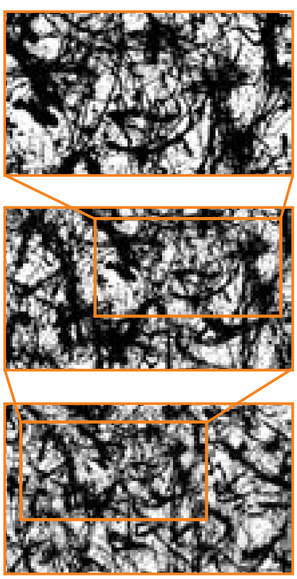
We have also analyzed five drip paintings sent to us by collectors who suspected their acquisitions might have been created by Pollock. Despite superficial similarities with Pollock's work, none of the paintings contained fractal patterns. The fractals are the product of the specific technique Pollock devised, and all the 20 drip paintings of his that we have analyzed have this fractal composition. We could therefore conclude that each of the five paintings sent to us for analysis was produced by someone other than Pollock. Fractality, then, offers a promising test for authenticating a Pollock drip painting. Further, because the $D$ value of the artist's work rose through the years, following a rather predictable trend, the analysis of the fractals can also be applied to date an authentic Pollock painting. —*R.P.T.*



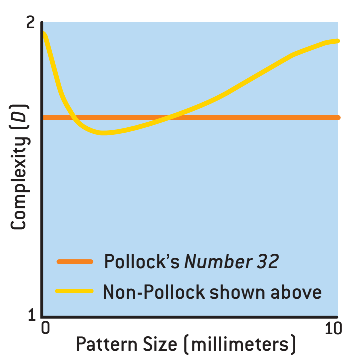
Non-Pollock drip painting, vinyl paint on canvas, 244 cm by 122 cm

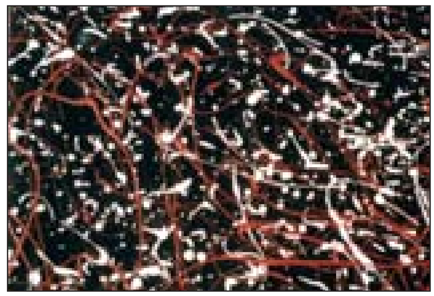


Non-Pollock drip painting



Pollock's *Number 32, 1950*





POLLOCK, shown above with Lee Krasner in 1950 while at work on *One,* famously said, “My concern is with the rhythms of nature.” At the right, from top to bottom, are the natural patterns created by seaweed, Pollock’s 1947 painting *Full Fathom Five,* and the author’s “accidental Pollock,” produced by a windstorm.



sistently expressed a preference for *D* values in the range of 1.3 to 1.5, regardless of the pattern’s origin. More recently, I teamed up with psychologist James A. Wise of Washington State University, and we showed that this visual appreciation has an effect on the observer’s physiological condition. Using skin conductance tests to measure stress levels, we found that midrange *D* values also put people at ease. Of course, these inquiries are just a beginning; still, it is interesting to note that many of the fractal patterns surrounding us in nature have *D* values in this same range—clouds, for example, have a value of 1.3.

What is the *D* value of Pollock’s work? Interestingly, the value increased over the decade that he made drip paintings, from 1.12 in 1945 up to 1.7 in 1952 and even up to 1.9 in a painting that Pollock destroyed. It is curious that Pollock would have spent 10 years refining his drip technique to yield high-*D* fractals if people prefer low-range to midrange values. The increased intricacy of high *D* values, however, may engage the attention of viewers more actively than the “relaxing” midrange fractals and thus may have been intuitively attractive to the artist. My current work at the University of Oregon is addressing this possibility, using eye-tracking apparatus to examine the way people look at fractals and at Pollock’s paintings.

Clearly, the computer’s expertise in detecting the fundamental characteristics of painted patterns offers art historians and theoreticians a promising new tool. It will join infrared, ultraviolet and x-ray analysis, which art experts already employ routinely, in a growing collection of scientific methods for investigating such features of art as the images hidden underneath subsequent layers of paint. Perhaps it may even be able to throw a narrow beam of light into those dim corners of the mind where great paintings exert their power. SA

## THE AUTHOR

*RICHARD P. TAYLOR* began puzzling over the paintings of Jackson Pollock while head of the condensed-matter physics department at the University of New South Wales in Australia. He is now a professor of physics at the University of Oregon, where he continues his analysis of Pollock’s work and investigates chaos and fractals in a variety of physical systems. He also has a master’s degree in art theory, with a focus on Pollock, from the University of New South Wales.

## MORE TO EXPLORE

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