Nonlinear Dynamics, Psychology, and Life Sciences, Vol. 13, No. 3, pp. 341-348.

Science and Art: Emergence of Patterns from Nature's Chaos, Through Parallels Between Edward Lorenz and Yves Klein

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Abstract: *Famous stories achieve their enduring appeal because they capture the essence of the times from which they emerge. This is true for both art and science. At critical moments in history, these two worlds become intertwined through a shared quest to understand the world around them. Questions hang in the air and, remarkably, accidents deliver the answers. In this chapter, I will explore the relationship between science and art as Edward Lorenz's discoveries unfolded to shed new light on the sensitive patterns hidden within nature's processes.*

Keywords: Lorenz, Yves Klein, patterns in nature, unpredictability; fractal geometry; Action Painting.

THE SEARCH FOR ORDER IN NATURE – PARALLELS AND ACCIDENTS

One day in the winter of 1961, Edward Lorenz was about to embark on his daily battle with weather forecasting using his state-of-the-art Royal McBee computer. The models in his program were simple when compared to the actual weather, but nevertheless captured the essential nonlinear qualities that drove the storms that pounded at his office windows through the long Boston winters. Setting his computer crunching through the equations, he walked down the corridor for his morning cup of coffee. On his return he discovered the seeds of chaos in the data that the computer had churned out. To save time, Lorenz had rounded some of the numbers fed into his computer – a tactic that unintentionally highlighted the fundamental sensitivity of his equations. This sensitivity allowed predictable processes to generate unpredictable patterns. Through a remarkable accident, the scientific distillation of nature's order from disorder had started in earnest.

Across the Atlantic in Paris, Yves Klien was facing his own battle with the weather. Nearing the end of his successful career as an abstract artist, Klein appeared unruffled by his agent's reminder of his previous commitment to

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deliver a painting to an influential gallery in Toulouse within the hour. As the agent spelt out the damaging ramifications of the fact that Klein had not even started the painting, he calmly asked for a reminder of the subject of the crucial painting. "Patterns in nature," replied the increasingly frustrated agent. Still unruffled, Klein looked up at the approaching storm clouds and announced that there would be no problem.

Attaching an empty canvas to the roof of his car, he drove south through the fury of the storm, feeling the canvas shake as the rain thrashed at its surface. Arriving in Toulouse only a little late, he handed the intricately stained canvas to the gallery owner, telling the owner how lucky he was – rather than having Klein's imitation of nature, the gallery now owned a pattern created by nature itself. Through this simple, unplanned act of employing a canvas to record nature's processes and patterns, the artistic distillation of nature's order from disorder had also started in earnest. Furthermore, striking parallels between scientific and artistic views of nature were unfurling.

Klein's adventure captured the prevailing mood within the art world in the mid-twentieth century. Time was running out for the abstract artists. Their remaining hope for salvaging modernism lay in grappling with nature's complexity and peering beyond its superficial haphazardness. Increasingly, artists were questioning if nature was simply masquerading as being disordered. Perhaps a hidden, subtle order was working away behind the scenes to build the rich and intricate displays that nature provided as the daily visual backdrops of their lives?

Some of the answers to this puzzle were already in place. Well before the 1960s, scientists and artists knew that aspects of nature were highly ordered. For example, Ernst Haeckel's epic *Art Forms In Nature* (Haekel 2008) from the 1860s and D'Arcy Thompson's elegant *On Growth and Form* first published in 1917 (Thompson 2007) featured many beautiful illustrations of intricate patterns found within nature. Both books also emphasized that nature is, in effect, teaching humanity a lesson in the process of generating patterns of art.

Nevertheless, both studies focused on the clean, euclidean patterns found within the structure of living entities, ranging from the human anatomy to sea creatures and on to plant forms. Both books purposefully stayed well clear of the messy everyday scenery provided by the fluffy clouds, the changing weather, the jagged mountains and the crazy swirls of turbulent water that shaped nature's scenery. So, as the 1960s dawned, the essential artistic question remained - were landscapes, seascapes and cloudscapes distinct from the ordered patterns found within living structures, or were these images also ordered? If this was the case, most artists agreed that nature's scenery was ordered using a very different geometry, one that was yet to be identified and understood.

This growing tension over the geometric significance of 'organic' art was responsible for considerable growing pains with modern art, fueling an epic aesthetic battle between the abstract artists. Piet Mondrian's abstractions, based on a skeleton of black straight lines and solid spaces of primary color, were clearly 'clean', mathematical and precise. Mondrian spent many torturous hours

adjusting the positions of his lines, often fine-tuning them by millimeters. From an art-world perspective, he clearly earned the label "geometric" abstraction by which his art forms became famous. If Mondrian's patterns claimed firm possession of the label "geometric", how would the art world handle the paintings emerging from other side of the battle lines – the 'organic' works that were spreading through the art world like wild fire? Were these paintings geometric or not?

The organic artists spearheaded the American Abstract Expressionism movement and its French counterpart, Art Informal, through the 1940s to 1960s. The principle stars of this organic era were Jackson Pollock, Franz Kline, Willem De Kooning, Mark Rothko and Clyfford Still. Pollock's wife was asked to identify the crucial skill that allowed her husband to succeed so majestically in creating his striking swirls of tangled webs of paint. She replied that his genius lay in his willingness to consider his complex, irregular images as actual patterns rather than haphazard messes. On Pollock's side of the aesthetic battle line, artists were no longer interested in the regularities and cleanliness of squares, circles and triangles, but in the irregularities of nature and the role of pattern in explaining this irregularity. Thus, by 1961, the search for hidden order in nature was accelerating for both artists and scientists. Something had to give - and accidents were waiting to happen. One involved a coffee break in Boston, the other a drive south to Toulouse.

By this time, Lorenz and Klein therefore shared a common intrigue as they watched the unpredictable weather fronts pass across their Bostonian and Parisian skylines. This courtship of the same question appears to be a recurring theme in the relationship between the arts and sciences. At certain periods in history, artists and scientists chase the same concepts, although they are inevitably expressed in their own specific language and techniques. Klein and Lorenz had only to look back to Pablo Picasso and Albert Einstein to observe an analogous courtship. At the start of the twentieth century, their shared puzzle was the unsettling consequences of the shift from classical to modern frame-works, with the observer's role moving from passive to active, whether it be in scientific experimentation or in the viewing experience in a gallery. Different 'observers' will 'view' the same object differently. With Einstein in Vienna and Picasso in Paris, the two great pioneers never met, nor did one directly influence the other. However, the shared dilemmas were "in the air" of those times, and no discipline was immune to the challenges of delivering the answers.

By the mid-Twentieth Century, the shared dilemmas of art and science had moved on from the Picasso-Einstein classicism-modernism struggle to the Lorenz-Klein visualization of nature's underlying processes and patterns. As with their predecessors, Lorenz and Klein would not have been directly influenced by each other's achievements. Instead, their common goal was again simply "in the air". For both Lorenz and Klein, the questions stirring the 1960s' interdisciplinary pot of nature were the following. Where was the balance between predictability and unpredictability – in particular, could predictable processes appear unpredictable? Was there order within nature's apparent

disorder? The first question concerns nature's processes, the second concerns the patterns left behind as a signature of those processes. Intriguingly, with these crucial questions open for debate, Lorenz's scientific world was about to deliver a helping hand to Klein's world of paintings.

PATTERNS AND PROCESSES

Lorenz's world had a healthy thirst for understanding physical processes. Although he was exploring nature's weather using a computer, his aim was clear – to see how the weather's processes evolved with time. In contrast, for the traditional 'classical' artists that pre-dating Lorenz's era, process was of secondary concern. They developed their artistic processes simply as a means of generating superior paintings. However, as the 1960s approached, the importance of artistic process began to shift ground in remarkable fashion. Action Painting began to flourish, a concept that had grown from the 1940s-1950s debate between two influential American art critics. Clement Greenberg celebrated the visual importance of the completed painting. According to Greenberg, the primary importance of an artwork lay in the aesthetic impact of painting's patterns. In contrast, Harold Rosenberg promoted the value of the Abstract Expressionists in terms of the dramatic and exciting painting processes that its members had developed to generate their patterns. One only has to witness films of Pollock's technique of pouring paint across his vast canvases to understand that his act of painting was an event in itself.

Thus, the organic artists faced a new dilemma that became known as 'Green mountain' versus 'Rose mountain.' Should the painting process assume more importance than the patterns left behind? Traditional artists, driven by superficial representations of nature, would undoubtedly answer 'yes'. But the tides were turning in the art world. Lorenz's discoveries of chaos took place at a time when Action Painting and its emphasis on process reached its peak in the public eye. The Surrealist art movement served as the springboard, but Klein's drive down to Toulouse was Action Painting at its most magnificent. Klein's previous 'happenings' were infamous and included smearing naked women's bodies with paint before dragging them across a horizontal canvas to the music of a live quartet of cello players. Although this was great entertainment, Klein knew full well that Action Painting succeeded in spectacular style when it harnessed and exploited a natural process. Pollock established a fine heritage with his declaration that "I am nature" when pouring paint, but Klein's drive south remains the peak of Action Painting by capturing a wild storm as it unleashed it power on the canvas.

By this time, chaos had started to gain a firm foothold in terms of its novel view of nature. Yet, just as Lorenz began to grasp the intricate repeating patterns within the dynamics of nature's processes, Action Painting was starting a rapid decline into confusion and was fast assuming a level of gimmickry that bordered on farce. One artist filled a balloon with paint and shot it with a rifle, another skidded across his canvas on a bicycle. Admittedly, there were

spectacular moments such as an artist using a jetliner's engines to blow paint across a huge canvas, but the spectacle lay in the event's size and the associated extravagance rather than any serious attempt to capture nature's events on canvas.

Action Painting was slowly and surely divorcing from the aesthetic quality of the resulting patterns. The painting was, in effect, becoming a mere memento of the 'happening' that had taken place. With the creation process beginning to dominate all artistic concerns, it was time for a reality check. Which is the more important – Klein's rain-splattered canvas or his remarkable drive through the storm? The same question can be leveled at the crashing waves and the intricate cliff face left behind. Science's answer is, of course, that both take equal emphasis in the understanding and celebration of nature. Around the same time as Lorenz's discovery of chaos, Benoit Mandelbrot had found recurring patterns at different scales in the behavior of cotton prices, starting his scientific journey toward the understanding of fractal patterns. Fractal geometry emerged soon after to describe the patterns left behind by nature's chaotic processes. The message to today's artists is therefore clear. There are no winners in the Greenberg versus Rosenberg battle. If your craft is to understand nature, then chaotic processes and fractal patterns take on equal importance.

LEGACIES

Lorenz's relationship with the art world is therefore a story with two parts. Part one took place during the 1960s, when Lorenz's scientific identify-cation of nature's chaos mirrored analogous developments in the art world. The two worlds traveled parallel to each other, neither one mimicking the other, both absorbing the new realities of nature. As Lorenz's chaos infiltrated the media and the public began to the grapple with this new scientific language, part two of the story finds the artists learning from, and being influenced by, Lorenz's lessons in chaos.

So what have today's artists learnt from Lorenz and his chaos? The balance of process and pattern, discussed above, is perhaps Lorenz's greatest legacy. The strength of its message lies in its generality. The same is true of another lesson coming out of chaos theory. Summed up as the famous "butterfly effect", small changes (e.g. a butterfly flapping its wings) can trigger huge consequences (e.g. a tornado in Texas). Of course, this principle is so entangled in everyday life that Lorenz wasn't the only messenger for this concept, nor was he the first. For example, Ray Bradbury wrote a short story "A Sound of Thunder" in 1952, in which the killing of a butterfly had profound consequences for society, including changing the outcome of a political election (Bradbury 1990). Nevertheless, Lorenz launched these basic ideas into huge popularity, in particular reaching out to the visual artists, fuelled by the high-octane language of scientific revolution.

It is interesting to consider why these legacies within the art world are attributed to Lorenz rather than his scientific predecessors. In particular, Henri

Poincare was the first to discover chaos's sensitive dependence on initial conditions back in 1890 when investigating the three-body problem. The answer lies in the fact that Lorenz had two distinct advantages over Poincare, and both proved attractive to artists.

Firstly, Lorenz's discovery directly impacted on that everyday phenomenon of weather. His discovery was therefore far from obscure! In doing so, the discovery exploited a shared interest in patterns to bridge the gap between art and mathematics. Previously, artists had listened with patience to claims by mathematicians and scientists that nature ran on mathematical formula (take, for example, Galileo's statement that "Nature's great book is written in mathematical symbols"). However, artists had only to glance out at the apparently patternless weather to see that these scientific claims held little currency for understanding the nature that the artists were trying to capture. With Lorenz's new formulae, artists could start to believe in a mathematical picture of nature. It became popular to view the spectrum of disciplines as a circle rather than a linear spread. Mathematics and art lay so far apart on this circle that they were actually neighbors. Far away and yet close.

Secondly, Lorenz used computers to visualize his chaos, a capability well beyond Poincare's era. In particular, as the power of computing has expanded, today's artists can generate Lorenz's chaotic patterns with relative ease. Consequently, computer images that capture nature's chaotic processes have assumed iconic status. In particular, the Lorenz attractor, introduced in 1963, has risen to such fame that its only challenger for the title of most popular mathematical image of all time is its counterpart from fractal geometry – the equally iconic Mandelbrot set. Whereas the Mandelbrot set looks like a hairy beetle, the swirling loops of the Lorenz attractor has the appearance of a beautiful butterfly about to take flight. Capturing the long-term patterns of chaotic flow, the butterfly stretches out in three-dimensional virtual space with a fractal dimension lying between two and three (2.06).

Given Lorenz's helping hand in the struggles of Action Painting, can we move beyond the virtual reality of computer art and consider a more fitting "happening" for nature's chaos? One appealing possibility lies with the pendulum – an object familiar both to chaotic studies and to artistic tradition.

The pendulum was known throughout the centuries as the epitome of stability. The predictable swing of the 'free pendulum' never falters. And yet it can be made to deviate with unsettling ease, causing it to descend into the unpredictability of chaos with just a little mechanical help. Whereas the free pendulum generates regular motion, a 'kicked pendulum', driven at a frequency only slightly different from its natural resonant frequency, can generate all the remarkable trademark signs of nature's chaos – an ordered pattern masquerading in disordered unpredictability. It can even generate Lorenz's chaotic attractor.

The pendulum also has an unmatched heritage within Action Painting. The Surrealists were the originators of Action Painting and one of their chiefs, Max Ernst, used a 'guided' pendulum. He grabbed a leaking container of paint as it swung on a piece of string and guided it through space with his hands, leaving

poured trajectories on the horizontal canvas below. A famous example is his "Young Man Intrigued by the Flight of a non-Euclidean Fly" from 1942.

These facts buzzed through my head one winter's day in February 1995. I had taken a year out from my scientific studies of chaos to investigate abstract art at Manchester School of Art in England. A group of art students were sent to the bleak Yorkshire Moors in the north of England with the basic instruction to paint the nature that confronted them. However, a viscous snowstorm settled in and the despondent students retreated to the warmth of their accommodations, unable to paint in the howling winds. It was then that I related the story of Klein, suggesting that they should harness the full fury of the winds and demand that nature paint for them.

The next day, we built large pendulum structures from the trees that had blown down in the winds of the previous evening. We attached sail cloth to the swinging mast that stretched up into the grey skies and bottles of paint to the other end. By mid-afternoon, as the sun began to set, the increasing winds allowed a test run and we saw the chaotic gusts knock the mast around in space, which then transferred its motion to the bottles below, sending paint splatters descending to a canvas laid out on the ground. As the winds gained strength and darkness fell, we retreated for the evening to let the storm perform its dance with the pendulum.

The next morning, the storm had cleared and we ventured out under spectacular blue skies to see the patterns left by the weather. It was then, in the bright morning sunlight, that we made the connection between the splatters of paint created by the chaotic winds and the famous patterns generated by Jackson Pollock's dashes across his canvases. On that morning, 34 years after Klein's drive to Toulouse and Lorenz's morning cop of coffee, it seemed like the worlds of Action Painting and chaos had once again collided. By accident, we had discovered the true significance of Jackson Pollock's organic patterns. Ten years before Lorenz's scientific discoveries, Pollock had made his own artistic discoveries concerning the chaotic motions of human balance. Although Pollock kept a copy of D'Arcy Thompson's book under his bed, he would not have known about the impending studies by Lorenz – however, the questions were already "in the air"

Looking back on these events, the true legacy of Lorenz's chaos becomes clear. Chaos provides an interdisciplinary bridge for understanding nature's patterns. Percy Snow's book *The Two Cultures* (Snow 1998) is often cited as the modern source of the infamous art-science 'divide'. Snow maintained that it was impossible for people from the arts and sciences to hold meaningful conversations. In reality, a shared enthusiasm and a common language is enough to conquer any divide. Snow's damming declaration was written in 1959. Two years later the enthusiasm of chaos was about to be unleashed and the inter-disciplinary quest to understand nature's patterns would herald the dawn of a new era.

ACKNOWLEDGMENTS

RPT is a Cottrell Scholar of the Research Corporation and a Research Scholar of the Andrea von Braun Foundation.

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