

Ants and Acorns: Some Thoughts on Complexity, Chaos, and the Therapeutic Relationship

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Having devoted much of my time over the past two years to a study of chaos and complexity, I find myself asking why the scientific community is so fascinated by these concepts, and what relevance they may have to the therapeutic encounter. I have gained some insights into the difference between determinism and the Chinese concept of *ming* (destiny, the "unfolding of original nature" [Rochat, 1992]) and the practical application of these concepts to our clinical work.

Chaos and complexity are aspects of systems theory. General systems theory, as first expounded by Bertalanffy in the 1930s and 40s, is based on the notion that all systems – whether physical, biological, or social – are united, not by similar contents, but by regularities of dynamic pattern. As Bertalanffy observed, "The Unity of Science is granted, not by a utopian reduction of all sciences to physics and chemistry, but by the structural uniformities of the different levels of reality" (Bertalanffy, 1968).

Bertalanffy was particularly concerned with and opposed to the attempt, on the part of reductionist/positivist science, to resolve biological phenomena into atomic entities and partial processes. He maintained that positivist science reduces living organisms to cells, its activities to physiological and, ultimately, physicochemical processes, its behaviour to unconditioned and conditioned reflexes, its heredity to particulate genes, and so on. He opposed this scientific perspective with the concept of "organism," and argued compellingly that it is necessary to study not only parts and processes in isolation, but also to solve the problems found in the organizations unifying them and to explore the dynamic interaction of parts instead of viewing each part in isolation.

Early systems theorists were intrigued by the observation that, while non-living systems seem to follow the Second Law of Thermodynamics (accumulating entropy), living systems exhibit the capacity to self-organize, generating higher levels of order. How to define a living system and what distinguished "life" from "non-life" were the central issues of their investigations.

The closing of the gap between the physical and the biological realms began with the relatively recent discovery that even aspects of the "merely material" world can, under certain circumstances, propel themselves into states of higher order, higher complexity, and higher organization.

The new sciences dealing with "self-organizing systems" are known collectively as the sciences of complexity, and include general systems theory, cybernetics,

nonequilibrium thermodynamics, cellular automata theory, catastrophe theory, autopoietic system theory, dynamic systems theory, and chaos theories.

Chaos

Chaos is a mathematical concept applied to the modelling of complex dynamic systems. In order to understand it, we must first understand the concept of an attractor.

All stable systems exhibit patterns of behaviour, which are stable because, after any disturbance, the system is "attracted" to its usual pattern. When a complex system is first established, it may exhibit transient behaviour, like a car when you first start it up or the turbulence in the flow of water from a tap when you first turn it on. But most systems eventually settle down to some sort of stability, and the form of this stability (the "attractor") can be mapped mathematically: for example, an unchanging value is represented by a point, and a regular oscillation by a wavy line or a loop.

There are three types of attractors:

1) Point attractors: Imagine a marble rolling around in a bowl and eventually coming to rest at the bottom of the bowl; the bottom of the bowl is the attractor. This is the ultimate stable state: in living systems, complete stability is equivalent to death.

2) Periodic attractors: This type of behaviour repeats itself continuously without significant variation (for example, machines that perform repetitive movements, or a planet in orbit). Many physiological systems display apparently periodic behaviour such as circadian thermal rhythms, the menstrual cycle, and the pulse.

3) Strange Attractors: Any structurally stable attractor that is not a point or a cycle is said to be a strange attractor. A strange attractor, when plotted mathematically, consists of orbits that never repeat exactly the same cycle, but never wander outside a limited region of space. The point moves erratically, but within certain boundaries. Because the point does not move outside these boundaries, the visual image created by such a mathematical representation has a characteristic shape.

Thus, a strange attractor is a mathematical depiction of a system that, paradoxically, has a predictable and recognizable overall form made up of unpredictable details.

Why has chaos become such a buzzword? Because it describes most of the phenomena we encounter in real life.

The Mechanics of Chaotic Systems: Feedback

The occurrence of these different types of attractor can be understood in terms of feedback. There are two general types of feedback. "Negative feedback" is the "feeding back" of information so as to keep the behaviour of a system in check, like the valve on a steam engine, which opens when the engine is running too fast in order to slow it down, but closes to keep the pressure up when the engine starts to slow down. In living organisms,

the classic example of negative feedback is temperature regulation: if there is a discrepancy of even 1°C from the body's set point, "thermometer neurons" in the hypothalamus alter their firing rate, which triggers an action either to warm or cool the blood. Warming is accomplished by increasing muscle tone and shivering, which increases heat production, and by curling up and constricting blood vessels in the skin to diminish heat loss. Cooling is achieved by loss of fluid through sweating and vasodilation in the arms, legs, and head. Both actions return body temperature to its thermal attractor of approximately 37°C. Through oscillations on a small scale, negative feedback calms disturbances to maintain homeostasis, which is essentially a point attractor.

"Positive feedback," by contrast, amplifies disturbances, and, if not countered by other influences, pushes systems to explode or spiral out of control. Familiar examples include the "feedback" that results when a microphone is placed too near its speaker, the careers of some pop stars and artists, the popularity of children's games, and fads that "catch on" and escalate, feeding on and multiplying their own impetus until they burn out.

Many dynamic systems and all chaotic systems exhibit a combination of negative and positive feedback. Negative feedback prevents the system from destroying itself or changing beyond recognition, while positive feedback amplifies small changes into large results, making the system extremely sensitive to external or internal environmental inputs. Positive feedback in orderly systems can cause complex and chaotic behaviour, and negative feedback in an otherwise chaotic system can organize and stabilize it. Combinations of these two types of feedback can be found everywhere in nature. In weather systems, for example, negative feedback works to keep the overall atmospheric temperature stable, while positive feedback can amplify a relatively small local perturbation into a major meteorological event. Because the planet's interlocking positive and negative feedback loops make the global system fundamentally chaotic, weather prediction is notoriously difficult in the short term, and simply not possible in the long term.

Chaos in living organisms is caused, in part, by the constant feedback that occurs when highly complex organic subsystems interact with each other according to various timescales: nervous impulses have a periodicity of fractions of a second, hormonal frequencies run between minutes and hours, "circadian" rhythms are normally between 22 and 28 hours, the menstrual cycle is normally around 28 days, and so on. Time delays on different scales build up so that the internal processes of the organic system are subtly, but constantly, shifting, lending a great deal of plasticity and adaptive potential to the system as a whole.

Scale

One property of chaotic systems is that their structure and behaviour on a large scale is reflected on a small scale. If you cut open a cauliflower so that its branching structure is revealed, you will see an exquisitely beautiful example of self-similarity of structure. Self-similarity is a fundamental characteristic of all natural systems and can be seen

everywhere around us – in coastlines, clouds, lightning, and rivers. Our own bodies are no exception: the vascular system, neural networks, the tracheobronchial tree, the bowel, and the brain are all "fractal" structures, displaying self-similarity on many scales.

Self-similarity breaks down at the ends of the spectrum of scale, that is, in the realms of the very large and the very small. You can measure the scaling of a coastline in greater and greater detail without significant qualitative change until you reach the molecular level. A flea can jump about a metre, but it would not be able to jump a thousand metres if it were magnified a thousand times; in fact, the poor creature's legs would break under its own weight.

The Chinese classics abound with poetic descriptions of our self-similar world. One of my teachers, Dr. Song Ke, related a story he was told as a child: humans have four limbs because the earth has four directions; we have hair because grass grows on the earth; our blood flows in its vessels because rivers flow on the earth; and we have two eyes because the heavens are lit by the sun and the moon. But the ancient Chinese also were aware of the points where self-similarity breaks down:

A small square is of the same class as a big square. A little horse is of the same class as a big one. But little knowledge is not of the same class as great knowledge. In the State of Lu there was a man called Kungsun Cho who said he could raise the dead. When they asked him how, he replied, 'I can heal hemiplegia (apoplexy). If I gave a double dose of the same drug, I could therefore raise the dead.' But among things there are some which can have small-scale effects, but not large-scale ones, and other things which can perform the half but not the whole. (From the Lu Shih Chhun Chhiu, cited in Needham, 1956)

Prediction and Explanation

In the philosophy of science, it has been argued that prediction and explanation are two sides of the same logical process, and differ only in the sense that predicted events have not yet happened, while explained ones already have. This would imply that every prediction counts as an explanation after the event, and every explanation counts as a prediction before the event. Neither of these two principles is true (Harre 1972).

We would not call the predictions made by nautical almanacs the explanation of the risings, settings, and conjunctions of the heavenly bodies. Characteristically, giving an explanation involves describing one or more causal mechanisms resulting in a particular event, and this may not be sufficient to allow prediction. We know at least some of the causal mechanisms of evolutionary change, but we are completely unable to predict the appearance of new forms of plants and animals. And, as Bertalanffy (1968) pointed out, professors of economics may be able to explain the mechanisms underlying economic trends (even this claim is open to debate!), but very few of them are millionaires.

On the other hand, we can predict a great many regular occurrences in our daily lives (including our clinical practice) without any explanation involving causal mechanisms, and sometimes without any explanation at all.

In chaotic systems, even when explanation is complete, prediction is not possible. If we map a chaotic system, and choose two points that appear indistinguishable (i.e., that have approximately the same value), and we follow the trajectories of these two points through time, we will find that they very quickly diverge to become two distinct trajectories. This will happen unless the two points are absolutely identical (i.e., unless their values are calculated to a precision that is infinite, which is, of course, impossible).

In a chaotic system, then, due to the combination of positive and negative feedback, even an unavoidably small discrepancy will rapidly grow, multiplying itself at an escalating rate, and making prediction all but impossible. This characteristic is known as sensitivity to initial conditions, and, in practical terms, it means that you cannot predict the exact behaviour of a chaotic system even if you understand the rules by which it functions. In other words, even when your explanation is complete and valid, not all of your predictions can lead to repeatable experiments.

You can, however, still make very accurate predictions – not of exact behaviour, but of its general qualitative nature. You can, for example, test whether a chaotic model of turbulence accurately describes the way a fluid behaves, but you cannot test whether a given fluid particle is obeying the dynamic equations.

Chaos in physiology

Many aspects of physiology, once considered "homeostatic," have been revealed to exhibit chaotic characteristics when inspected at a different scale or through more refined methods of mathematical analysis. Consider the following examples:

- EEGs of healthy individuals have shown evidence of chaos in the central nervous system. By contrast, several types of pathology including epilepsy, tremors, and manic-depressive oscillations are characterized by a loss of complex variability and the appearance of a too-regular periodicity (Briggs, 1992).
- Recordings of brain activity, made while people performed various tasks, revealed that the complexity of the patterns changed in response to changes in intellectual effort, with higher-dimensional, more complicated EEG patterns apparently corresponding to a more alert state (Briggs, 1992).
- It has been found that white blood cell counts in healthy individuals fluctuate chaotically from day to day, while periodic oscillations occur in certain cases of leukemia (Briggs, 1992).
- Hormone levels in healthy individuals seem to undergo chaotic fluctuations.

· Research on the chaotic dynamics of cardiac function indicates that the heart rate in healthy individuals, even those at rest, is neither constant nor strictly periodic, but displays complex irregularities, which vary on timescales from seconds to days. A number of pathologies, including heart rate patterns preceding sudden cardiac arrest, are characterized by increasingly periodic behavior and a loss of complex variability, as are heart dynamics associated with aging (Goldberger, 1991).

Chaos is the interaction of a number of different frequencies, producing a complex pattern; too much order may reflect a lack of responsiveness to a variety of inputs and a lack of integration with the rest of the body. The diseased heart apparently begins to disconnect itself from the myriad messages of the whole organism and responds to only a few stimuli (Goodwin, 1995).

Perhaps what we term "stress" really arises from the ubiquitous psychological threats of modern life, which are, as far as the body is concerned, false alarms; still, unwinding from an alarm, even a false one, is a much slower process than jumping to alert, which takes only a second. It can take many minutes, sometimes hours, for the body to return to a state of relaxation. If we don't have time to recover from one alarm before the next one is triggered, our bodies remain in a permanent state of emergency. This may not be dangerous in itself, but it decreases our physiological variability.

Health is a condition of responsiveness and sensitivity to a wide range of different variables, a state of adaptability and openness to change, which is, at the same time, supported by a stable core, bounded by that strange attractor which defines one's essential nature as a member of a species, a participant in broad natural and social systems, and as an individual. As therapists, we aim to help our fellow beings attain and maintain a state of dynamic balance in which they are both stable and changing, bounded and responsive, yin and yang.

The "Edge of Chaos"

The desirability of this state of balance is demonstrated by the fact that most living systems seem to thrive best somewhere near the border between rhythmic regularity and chaos. For example, recent research with ants (Goodwin, 1994, 1996) has shown that an individual ant, in the absence of interaction with other ants, fluctuates between activity and rest in a random pattern. As it interacts with other ants, however, one can observe order "emerging from chaos": as the population of the colony increases, its density increases, eventually reaching a critical point where the colony as a whole starts to demonstrate a rhythmic oscillation between activity and rest.

Of particular note is that the frequency of interactions between ants is determined by the density of the colony, and the colony regulates its own density: if the walls of the nest are moved, the ants will adjust them inward or outward as necessary to ensure their ability to interact in this orderly manner. But the colony functions just on the border between order

and chaos; if 8-10% of its population goes out foraging for food, the density drops and the remainder of the colony temporarily reverts to chaotic patterns of activity.

What is significant here is that the order within the colony emerges spontaneously from its own dynamics, rather than being imposed from without. It is not known why the ant colony functions in this way, but the emergence of order through interaction does seem to be a universal quality of living systems.

This strikes me as a metaphor for the way that my own life and those of my family, friends, and patients proceed. At our normal level of "density," we have a more or less comfortable level of interaction, and, all being well, order emerges in our lives. But at other times, either because our "walls" have been moved by events beyond our control or because we ourselves have gone out "foraging" for new experience, our lives become chaotic. And because, as human beings, we have (I hope) a greater capacity for creativity than ants, we can generate new types of order out of this chaos, so that we may continually "begin again."

The Yin and Yang of Order and Chaos

Chaos theory is one way of attempting to map a complex reality, but, of course, all maps of reality are, in principle, flawed, incomplete, or, at best, oversimplified. The scientist aspires to map that which already exists, teasing out the principles behind the regularities in both structure and process. The artist and the mystic ride the wave of the always-now, flowing around and into the gaps in regularity, celebrating the novel, the anomalous, and even the unlawful; in Chinese terms, they pursue the *ji*, the "irrational numbers" – the irregular bit that doesn't fit, the fragment that is left over after the world has been ordered into regular divisions.

Perhaps it is the tension between these perspectives that drives creativity, which is manifest as an oscillation between two modes of meeting the world, now dreaming the impossible dream of grasping it intellectually, now colliding with the elusive yet "hard" reality of the incongruous – those things and events that don't belong and that shouldn't, according to our constructed systems of understanding, exist at all. This is another sense of the "edge of chaos."

As science progressively generates explanations for physical phenomena at the level of structured regularity, the horizon continues to recede. New discoveries throw spanners into the works, reminding us that it is the flux of yin and yang that powers not only the natural world but our participation in it.

Seeing the Order in the Chaos

The American psychologist James Hillman (1995) describes the process of "mentoring," which, I feel, is the key to bringing all these concepts together and establishing their relevance to the therapeutic relationship. Hillman's thesis is that "Each person comes into the world with his or her own genius . . . something that is not the result of your parents or the environment but is particularly your destiny." Perhaps we could consider individuals

as unique "strange attractors," determined only by their place in the universal *tao*: their potential infinitely varied, but bounded by their own distinctive shape.

Our distinct character will be present, in a self-similar manner, in every aspect and stage of our lives, and it is thus possible for another person to recognize the "acorn" in us, our particular genius as yet unmanifest – what we might become. When someone sees the unique aspect of another, the element that cannot be contained within categories and typologies – which is to say the "irregular" or "extraordinary" – an interpersonal space is created in which that uniqueness can blossom and come to fruition. Hillman speaks of "the necessity of being seen in order to be," and declares "Such sight blesses; it does transformative work."

Chinese philosophy has never divorced the regular from the irregular, the objective from the subjective, nor fact from meaning. This is exemplified by the belief that the quality of life and health is dependent on the development of specifically human qualities. The crucial human quality celebrated by Taoism is that of "spontaneity," which is only possible when one rejects fixed rules of conduct and intuitively grasps all the relevant aspects of one's situation, without the clouding of consciousness that results from identifying with one's desires and aversions. From the perception of one's situation with perfect clarity, spontaneous inclination moves inevitably in the right direction, and the Western dichotomy between freedom and determinism dissolves in the unity of spontaneity and inevitability. The Taoist rejection of fixed rules of conduct illustrates the Chinese focus on the complex nature of process; it highlights the uniqueness of all situations, which are, nevertheless, bounded by rules of transformation. In medicine, this translates into an emphasis on an individualistic approach to health care. Whereas in contemporary Western medicine, diseases and disease agents have an ontological status, in Chinese medicine disease is traditionally viewed as an ongoing process in a unique individual. The classics tend to avoid not only the reification of disease but also the reification of health in the sense that we understand it in the West, for one person's state of health cannot be the same as another's.

The Therapeutic Technique and the Therapeutic Relationship

Our patients, too, live their lives on the edge, and if our therapeutic work aims to restore homeostasis, we will proceed differently than if we aim to facilitate our patients' creative self-transformation.

Realization of the full potential of therapeutic work requires that we maintain a tension between regularity and uniqueness, order and chaos, the predictions of scientific law and Taoist spontaneity. Diagnosis demands that we categorize; in essence, it is an activity that consists of placing the patient within a conceptual structure. The therapeutic relationship, on the other hand, demands that we see the uniqueness, the genius, within the person – and this applies equally to all systems of healing, modern or traditional.

When we diagnose, we work within a deterministic system; we can predict – at least in a general way – the course of disease and the effects of our interventions. By assisting our

patients to regulate their state (as ants regulate the density of their colony), we allow them to restore their own internal order.

Truly transformational work requires us to see into the acorn "with the eye of the heart" and facilitate the emergence of creative growth and the realization of unsuspected potential.

"Patients" relate to "practitioners," "physicians," or "therapists" -- whichever term you choose for the professionalized persona of the healer. But "persons" relate to "persons." If we wish to engage in transformative – as distinct from, and in addition to reformative – work, we must engage with the person, and we can do so only as persons ourselves, in all our glorious and messy complexity.

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