

## Chaos, Complexity, and Creativity

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### Abstract

During the workshop, we introduce the main concepts and principles of chaos theory (positive and negative feedback, bifurcation points, attractors, complexity, self-organization, dissipative structures) through brief introductions, discussions, and a variety of stimulating and interactive activities like improvisation, active imagination, exercises of self-reflection, and techniques of disappearing. To illustrate some concepts we use the author's paintings. Then we analyze the process of creativity by applying these concepts. Creativity could be referred to as "self-organizing dissipative structures," originating spontaneously in far-from-equilibrium conditions. They emerge only through a constant exchange of energy/information with their environment, continuously create bifurcation points of instabilities and fluctuations, and transform themselves into new organization of increased order and complexity.

### Introduction

In this workshop I will introduce the basic concepts of chaos theory and analyze the process of creativity by applying these concepts. I will guide the participants through a variety of stimulating and interactive activities like improvisation, active imagination, exercises of self-reflection, and disappearing techniques designed to assist in understanding and increasing their creativity.

During the early eighties chaos theory, nonlinear dynamics, fractals, and self-organization were widely discussed and employed in a variety of physical, chemical and mathematical problems.

Now, chaos theory is actively applied to almost everything from psychology to neuroscience, from economics to social dynamics.

A number of researchers have accumulated experimental evidence that the brain is a nonlinear feedback device and some studies show that diverging thinking, considered the general process underlying creative production, can be distinguished from convergent, analytical thought based on the dimensional complexity of ongoing electroencephalographic (EEG) activity [1]. This shows that irregularities (chaos) lead to complexity. Chaos is what makes life and intelligence possible.

### Chaos Theory

*"We believe that chaos represents the true nature of most psychological phenomena. It provides the alphabet of thought, because it represents the complexity of mind, brain, and behavior. We believe that chaos is the archetype that drives the universe, is its deep structure."*

*Frederick Abraham [2, p. xxvi]*

In the last thirty years, new ways of study and understanding of complex systems have emerged – called chaos theory. Chaos theory acts as a conceptual umbrella for various approaches and explorations of complex systems, like dynamical system theory [3], self-organization [4-5], fractal geometry [6], catastrophe theory [7], theory of dissipative structures [8-11], and complexity theory [12].

Chaos theory studies open, nonlinear, and dynamic systems that constantly interact with and adjust to their environment, changing, growing, learning, and evolving. Chaotic systems exhibit an *extreme sensitivity to their initial conditions*, called popularly the “*butterfly effect*.” Slight differences in their starting points make a very large difference in their outcomes. Such systems are highly sensitive because they are always changing through the loops of *positive and negative feedback*, and never precisely recycling to their initial states. Systems that change radically through their feedback are said to be *nonlinear*. In some conditions nonlinear systems behave in a regular, cyclical manner until something sets them off; a critical point is passed and suddenly they go chaotic. This critical point where a system changes character of the motion is a *bifurcation point*, and the states of chaotic motion are *attractors*.

### Negative and Positive Feedback

In chaotic systems, everything is connected to everything else through *negative and positive feedback* [13]. Negative feedback keeps things in check and regulates the stability of a system. Positive feedback pushes a system for change, where more leads to more and less to less. Sometimes positive feedback drives a system to explode or spiral out of control. One of the most important discoveries of chaos theory has been that positive feedback can cause complex, even chaotic behavior to unfold inside orderly systems. Also that negative feedback can grow inside an otherwise chaotic system, suddenly organizing it and making it stable. Theory of chaos and complexity encourages us to understand how change unfolds through circular patterns of interactions.

*Activity I: Improvisation is the root of creativity and can lead to the discovery of new ways to act and new patterns of thought. Improvisation excites self-expression areas and suppresses self-control regions in the brain.*

- “*Make a scene using the concepts of positive and negative feedback*”

*In this exercise between two people, one person is given the role as the leader. That individual is given an opening sentence, which is spoken aloud. The second person uses that sentence (paying attention to the tone and words) to “create” a scene that makes sense.*

- “*Become the psychologist*”

*This exercise involves you becoming a psychologist and by using your imagination, you have to talk about a subject chosen by the leader. The purpose of this exercise is to introduce the concept of an attractor.*

### Attractors

*Attractors* [13-17] characterize the behavior of a system; the same system can evolve into different types of attractors during its development.

There are three types of attractors: (a) point attractor, (b) periodic attractor, and (c) strange or chaotic attractor.

The most predictable one is *the point attractor*, when the system moves toward it in a condition of asymptotic stability. An example of the point attractor from life dynamics is a fixation on one desire or addiction to drugs, to alcohol, to success, to sex, or to some idea. It leads to monotony, to misery, to depression and very often to death. It is a single-minded attractor: black or white, good or bad, hate or love.

To the group of *periodic attractors* belong a cycle attractor and a torus attractor. *The cycle attractor* has the ability to resist change. Both the point and the cycle attractors describe systems that are highly regular, and thus, predictable. Routine is the perfect life example for the cycle attractor: when we are attracted to two activities, we tend to oscillate between them (e.g., work and family). Another example is our egocentric desires to acquire wealth, power, fame, and to have pleasure of one sort or another. This state of life, when we are moving from one situation to another, fluctuating from one mood to another, and repeating the very same process again and again, brings only dissatisfaction and suffering.

The three-dimensional periodic attractor is *the torus attractor*. It has a higher degree of regularity and complexity than the cycle attractor, but the pattern is again fixed and finite. The torus attractor expresses, for example, a complex set of attracting events that occur to a person on many levels over the course of a year. Then these events repeat again, year in and year out.

The *strange or chaotic attractor* describes systems that are in a state of turbulence, such as weather, violent river, brain activity, or our life dynamics. In general, the chaotic attractors can take an infinite number of different forms. Their patterns are fantastic, complex maps that capture the interplay between stability and change in a system. For example, a chaotic attractor portrays our state of consciousness, as a combination of moods, thoughts, memories, and images. They are constantly changing, memories come and go, thoughts pass through the mind only to disappear and return again later and so on. Consciousness exhibits periods of calm, periods of more or less regular oscillations, and periods of chaotic activity. The ability of a system to move in and out of chaos gives it a creative advantage.

Essentially, a chaotic attractor is a process that unfolds through the complex interactions between elements in a system. It is through a pattern of folding and stretching that the structure of the chaotic attractor emerges. Chaotic attractors are the foundation for hidden order in natural systems.

*Activity II: Analyze your state; which attractors best describe your actual life dynamics. How do you express your state in the form of art (painting, poems, and music)?*

## Bifurcations

*Bifurcation is a source of innovation and diversification.*

*Nicolis & Prigogine [8, p.74]*

In nonlinear dynamic systems, through the process of positive feedback, abrupt changes of behavior can be observed. These changes called *bifurcation points* [4], [8 -11] occur when system orderliness breaks down, sensitivity to perturbations increases, and new patterns of organization rapidly self-amplify. Far away from a bifurcation point, a system can be well behaved; but as a bifurcation is approached, the system's trajectory becomes random and unpredictable (large fluctuations occur). At this point, the system "hesitates" among various different possible directions of change. Even little fluctuations in the subsystems can combine through positive feedback loops, becoming strong enough to shatter any pre-existing organization. At this point, the disorganized system either disintegrates into chaos, or leaps to a new higher level of order of organization.

When we think of ourselves as nonlinear, dynamic systems, bifurcation points can be viewed as special events along the flow of our lives during which choices can be made to influence future possibilities.

Psychological bifurcations are the rapid transformations of sensory, perceptual, cognitive, and affective experiences that may radically alter our lifestyle. They appear in the process of learning, in motivational states, in brain activity, in developmental stages and in their associated increasing complexity, in personality and family organization [18]. Here are some examples of psychological bifurcation points: a) "Aha!" moments or insight experiences: when rapid perceptual or cognitive restructuring takes place in the context of working on a difficult problem; b) moments when we

experience overwhelming emotional transformations (e.g. falling in love); and c) the moment when "of body" information rises to attention (e.g. feeling of hunger) [19].

*Activity III: Reflect upon your life using concepts of attractors, bifurcation, and positive and negative feedback. How do you apply this self-reflection to your art?*

## Complexity

Complexity theory, which has been developed in the last twenty years, appears to be applicable to an enormous range of phenomena in physics, chemistry, social sciences, economy, psychology, neuroscience, and many more. Complex systems are everywhere; they are our bodies, our brains, our society, our culture. These systems contain many elements interacting reciprocally and nonlinearly by positive feedback mechanism. Two dimensions of *differentiation* and *integration* characterize complex systems. Differentiation means variety, it means that the different parts of the system behave in different ways. Integration, on the other hand, means to link the component parts to one another. Complexity arises when both of these aspects are present [20].

The science of complexity shows how a spontaneous process of *self-organization* can take place when a dynamical system finds itself in a state that is far from equilibrium, without any external force acting on the system.

## Self-organization and Dissipative Structure

*"At equilibrium molecules behave as essentially independent entities; they ignore one another. However, non-equilibrium wakes them up and introduces coherence quite foreign to equilibrium. This is the concept of "order through fluctuations."*

*Prigogine and Stengers [10, p.180]*

All living [5] and psychological [21-22] systems evolve through the process of self-organization. An open, nonlinear and complex system acquires a new state without specific interference from the outside. With a continuous change in one or more control parameters, new states emerge spontaneously purely as a function of the dynamics of non-linear interactions between the system's components. The control parameter creates the necessary conditions for far from equilibrium states and critical fluctuations. Near equilibrium fluctuations are harmless, but far from equilibrium, they play a central role. Fluctuations are continuously probing the system and providing an opportunity to discover new patterns. The emerging patterns are created by the coordination between the parts of the system, but in turn influence the behavior of the parts. This is called a circular causality [23].

Prigogine introduced the concept of *dissipative structures* [8-11]. Such structures, to maintain their existence, must interact with their environment continually, maintaining the flow of energy into and out of the system. Self-organizing system becomes more ordered and more complex over time. Through this process, the system generates something new, unexpected structures, patterns, properties known as *emergence* [20].

The human brain is an example of a complex adaptive system in which single neurons interact in simple ways yet their collective neural network produces highly complex properties such as creativity and consciousness. Creativity and consciousness are examples of emergence. The interaction of the processes that form a complex system such as the mind - thoughts, images, memories, and so on - give rise to new processes. These new processes now interact with the original ones to create yet other novel processes, second order emergent events, and these are in principle entirely free and unpredictable.

*Activity IV: Techniques of disappearing invented by Keith Johnstone [24]*

*All participants are asked to open eyes as widely as possible and on a signal start to walk around the room, point at any and every object, and shout as loudly as possible the wrong name.*

*Purpose: To look by fresh eyes on our surroundings. All our habitual overlays of interpretation and conceptualization are removed from the objects and people in front of us. This chaotic state can be described by a pure awareness of things-in-themselves. As adults, we can often give our best performances when we are not aware of ourselves and able to suppress our egos.*

### **The Process of Creativity**

*“Creativity is a very paradoxical state of consciousness and being.*

*It is action through inaction.*

*It is allowing something to happen through you.*

*It is not a doing, it is an allowing.*

*It is becoming a passage so the whole can flow through you.*

*It is becoming a hollow bamboo, just a hollow bamboo.”*

*Osho [25, p.31]*

Creativity as an extremely complex process is generally defined very broadly as the capacity to bring something new into existence. Rogers’ definition [26, p. 139] that “the creative process is an emergence in action of a novel relational product, growing out of the uniqueness of the individual and materials, events, people, or circumstance of his life” is the closest to our understanding of creativity.

We show that creativity could be described as “self-organizing dissipative structures” originating spontaneously in chaotic (far-from-equilibrium) conditions.

### **Chaos – The Differentiation Phase**

When we approach some challenging, open-ended problems, we plunge into the process of questioning, researching, collecting, and exchanging of information. We work under conditions of emotional fluctuations, tensions, internal conflicts, doubt, and uncertainties.

Our mental state could be described by a variety of chaotic attractors like passion, love, knowledge, freedom, etc. They are constantly changing, interacting, bifurcating from one to another through the loops of positive and negative feedback. Since an enormous amount of information is created, this is the *differentiation* phase.

During this time we have to be “open” to the external and internal environment. Rogers [26] writes that in the person who is open to experience each stimulus flows freely through the nervous system. Whether the stimulus originates in the external or internal environment, it is available to our awareness. This means that we are aware of this existential moment as *it* is. We are able to accept ambiguity and to receive a considerable amount of conflicting information.

Sometimes we reach a point at which we become overwhelmed or blocked by contradictions, difficulties, and inconsistencies. In this situation we should willingly bifurcate to a different state. We should relax, go for walk, meditate, take a nap or start other project, and rely on our unconscious.

*Activity V: “Dream and its Images” - Exercise based on Jung’s “Active Imagination”*

*Participants choose a partner. They sit quietly and one tells the other about his/her dream. The partner listens with attention and then asks a participant to choose an image from his/her dream. Then they act*

*out on the image. They associate to the image. What does the image remind them of? What associations do they have with it? They switch roles. Now the second participant tells a dream to the first, and so on.*

*Purpose: An active imagination is a state of readiness, and through this process, the images from the unconscious are clarified and brought closer to consciousness. Sometimes active imagination takes place mainly inside our minds. Other time, the imagination is given form through painting, drawing, writing, and so on. As an example we will discuss a painting “Persona”, which I painted after having a dream.*

### **Complexity – The Integration Phase**

The second phase refers to “the process of removing a problem from conscious awareness temporarily as means of gaining new perspectives on how to solve it” [27, p.389]. Free from rational direction; ideas, thoughts, images, and memories can combine and pursue each other every which way. Because of the freedom, original and new connections have a chance to be established. These new connections now interact with the original ones to create yet other novel processes, second order emergent events, and these are in principle entirely free and unpredictable.

Both increasing order and increasing complexity rely on a basic mechanism of self-organization, the coupling of reciprocally interacting system elements. Through this process, the system generates something new, unexpected structures, patterns, properties known as emergence. The emergent phenomena can be understood on a higher level than the lower level components they emerged from. This is generally the *integrative* process. Complexity arises when differentiation and integration are present. It increases when the number and/ or variety of the elements (thoughts, images, memories) that constitute our mind increase and when the number of relations that link them, i.e. the degree of integration between the elements, increases.

Contrary to the conscious brain, the unconscious brain appears to be a parallel processor, so that novel combinations of information are constantly generated, regardless of the state of attentional control [28].

Neuroscientists [1] show that divergent thinking, considered the general process underlying creative production, can be distinguished from convergent, analytic thought based on the dimensional complexity of ongoing electroencephalographic (EEG) activity. EEG complexity was comparable during divergent thinking and mental relaxation, but reduced during convergent thinking. Results indicate that the basic process underlying the generation of novel ideas expresses itself in a strong increase in the EEG’s complexity, reflecting higher degree of freedom in the competitive interactions among cortical neuron assemblies. Frontocortical EEG complexity being comparable with that during mental relaxation, speaks for a loosened attentional control during creative thinking.

### **Creativity – The Dissipative Structures**

*“One evening, contrary to my custom, I drank black coffee and could not sleep.  
Ideas rose in crowds;  
I felt them collide until pairs interlocked, so to speak, making a stable combination...”  
Poincare [29, p.81]*

The spontaneous insights, the “Aha!” moments, and the new ideas usually become conscious by appearing in a working memory during periods of mental relaxation after hard work and mental and emotional struggle.

They are a result of a successful self-organization of the chaotic activities in the unconscious. They are unexpected and unpredictable. They emerge at the “edge of chaos” as an expression of a new order that originates spontaneously from inside the system itself and creates completely new “emergent

property”: a new picture, a new mathematical function, or a new song and so on. They are dissipative structures [8-11]. Usually the moment of insight is itself a dense, wordless, and sensory experience. Mihaly Csikszentmihalyi [30] mentions that most people recall with great intensity and precision a particular moment when some major problem crystallized in their mind in such way that a solution become all but inevitable, requiring only a matter of time and hard work.

*Activity VI: Close your eyes and think about moments when and how you experienced an insight (your mental and external conditions) and what happened next.*

After an insight occurs, one must check it out to see if the connections genuinely make sense. When we are being immersing in chaos, bifurcation happen and moments of flow appears. The flow introduced by Mihaly Csikszentmihalyi, is the period in the creative process when self-consciousness disappears, and is total absorption in the activity. It is the most enjoyable process any human can be involved in. The main elements of flow experience are: (a) immediate feedback to one’s action; (b) balance between challenges and skills; (c) action and awareness are merged; (d) no worry of failure; (e) sense of time becomes distorted [31].

### Summary

We demonstrate here how chaos theory describes the complex process of creativity. Chaos stimulates creative thinking and creates a necessary condition to initiate the process of self-organization. In the first phase of the process of creativity, the diversity of elements of knowledge appears to be essential. Then through the process of self-organization, these elements; thoughts, ideas, images, and memories interconnect freely and spontaneously and create a completely new organization of an increased order and complexity.

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