

Part II: Synthesis of Concepts from the Complexity Sciences

Complex Adaptive Systems

In his introduction to Complex Adaptive Systems, Bryan Coffman presented key characteristics of systems, of adaptation and evolution, and of Complex Adaptive Systems.



1. characteristics of systems

1. A system is combination of things forming a unitary whole. It could be innate or the construct of an observer's. Examples: an ant colony, a tree, a human being, a corporation, a market.
2. The behavior of such a system is not predicted by the behavior of its parts.
3. Its behavior is characterized by feedback loops (positive and negative). Negative feedback is goal + homeostasis seeking. Positive feedback is unbridled growth or decline.
10. Parcellation typically speeds evolution: greater selection pressure is found at the margins of habitats (rising sea level)
11. Local extinctions speed evolution because they create empty niches

2. characteristics of adaptation & evolution

1. A reasonably complex pattern must be involved
2. The pattern must be copied somehow
3. Variant patterns are sometimes produced by chance; other times by combination
4. The pattern and its variants compete with one another for limited space or resources
5. The competition is biased by a multifaceted environment
6. There is skewed survival to reproductive maturity or a skewed distribution of adults who successfully mate so that new variants preferentially occur around the more successful of the current patterns
7. Stability may occur (stable basin of attraction)
8. Systematic recombination generates many more variants than mutations/chance
9. Fluctuating environments change the name of the game
3. characteristics of complex adaptive systems
 1. Composed of a number of agents
 2. Agents typically follow simple rules
 3. There is often a pre-existing or emergent goal
 4. Agents combine building blocks of some sort to create strategies for achieving their individual goals
 5. The pattern of independent & interdependent behavior of agents creates a number of emergent characteristics—many simple components interacting simultaneously
 6. Most CAS have several levels of organization: agents at one level serve as building blocks for agents at higher levels (employees, firms, industries, economies)
 7. Agents make predictions based on their own internal models of the world
 8. CAS anticipate the future
 9. CAS typically have many niches, or places to be exploited and occupied through adaptation
 10. The control in CAS tends to be highly dispersed
 11. Agents use heuristics or rules of thumb in decision-making because the combinatorial possibilities are too large to analyze

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The diagram below, also presented by Bryan Coffman shows a process-oriented view of the behavior of a complex adaptive system.

1. **Multiple agents** compete, collaborate, and cooperate.
2. They adopt **individual strategies** based on their goals, and their predictions of the future.
3. As a result of their aggregate actions **outcomes** are achieved; things happen in the environment.
4. The **environment** itself is a non-level playing field that also fluctuates independently of any individual's influence, and in aggregate demonstrates **emergent behaviors**, ie, those that could not be predicted based on the characteristics of individual agents alone.
5. The continued viability of any system requires **Adaptation**, which may be driven by mutation, combination, or extreme conditions.
6. Adaptation yields fitness to the environment,
7. and allows for the selection of new goals.

The process, of course, continues indefinitely for as long as the system persists as a system, with individual agents meeting their individual fates along the way.

