Self-Organizing System

Self-organization is a process where a system reproduces itself with the help of its own logic and components (i.e., the system produces itself based on an internal logic). Self-organizing systems are their own reason and cause; they produce themselves (*causa sui*). In a self-organizing system, new order emerges from the old system. This new order can't be reduced to single elements, it is due to the interactions of the system's elements. Hence, a system is more than the sum of its parts. The process of the appearance of order in a self-organizing system is termed *emergence.* The logic underlying self-organizing systems resembles the dialectical principles of the transition from quantity to quality, negation, and negation of the negation.

Characteristics of Self-Organizing Systems

Self-organizing systems have a multitude of characteristics, including the following:

Systemness—Self-organization takes place in a system, in a coherent whole that has parts, interactions, structural relationships, behavior, state, and a border that delimits it from its environment.

Complexity—Self-organizing systems are complex systems. The term *complexity* has three levels of meaning: (1) There is self-organization and emergence in complex systems. (2) Complex systems are not organized centrally, but in a distributed manner; there are many connections between the system's parts. (3) It is difficult to model complex systems and to predict their behavior, even if one knows, to a large extent, the parts of such systems and the connections between the parts. The complexity of a system depends on the number of its elements and the connections between the elements (the system's structure).

Control parameters—A set of parameters influences the state and behavior of the system.

Critical values—If certain critical values of the control parameters are reached, structural change takes place and the system enters a phase of instability and criticality.

Fluctuation and intensification—Small disturbances from inside the system intensify themselves and initiate the formation of order.

Feedback loops, circular causality—Feedback loops occur within a self-organizing system; circular causality involves a number of processes: p1, p2, . . . , pn ($n \geq 1$), and p1 results in p2, p2 in p3 , . . . , pn-1 in pn and pn in p1.

Nonlinearity—In a critical phase of a self-organizing system, causes and effects cannot be mapped linearly: Similar causes can have different effects and different causes similar effects; small changes of causes can have large effects, whereas large changes can also result in only small effects (but nonetheless it can also be the case that small causes have small effects and large causes have large effects).

Bifurcation points—Once a fluctuation intensifies itself, the system enters a critical phase where its development is relatively open, certain possible paths of development emerge, and the system has to make a choice. This means a dialectic of necessity and chance. Bifurcation means a phase transition from stability to instability.

Selection—In a critical phase that can also be called the point of bifurcation, a selection is made between one of several alternative paths of development.

Emergence of order—In a critical phase, new qualities of a self-organizing system emerge; this principle is also called order from chaos or order through fluctuation. A self-organizing system is more than the sum of its parts. The qualities that result from temporal and spatial differentiation of a system are not reducible to the properties of the components of the systems; interactions between the components result in new properties of the system that cannot be fully predicted and cannot be found in the qualities of the components. Microscopic interactions result in new qualities on the macroscopic level of the system. The emergence of order includes both (a) bottom-up emergence (a perturbation that causes the system's parts to interact synergetically in such a way that at least one new quality on a higher level emerges) and (b) downward causation (once new qualities of a system have emerged, they, along with the other structural macroaspects of the system, influence—that is, enable and constrain—the behavior of the system's parts). This process can be described as a top-down emergence if new qualities of certain parts (seen as wholes or systems themselves) show up.

Information production—Self-organizing systems are information-producing systems.

Fault tolerance—Outside a critical phase, the structure of the system is relatively stable concerning local disturbances and a change of boundary conditions.

Openness—Self-organization can only take place if the system imports entropy that is transformed; as a result, energy is exported or dissipated.

Symmetry breaking—The emerging structures have less symmetry than the foundational laws of the system.

Inner conditionality—Self-organizing systems are influenced by their inner conditions and the boundary conditions from their environment.

Relative chance—There is a dialectic of chance and necessity in self-organizing systems; certain aspects are determined, whereas others are relatively open and subject to chance.

Hierarchy—The self-organization of complex systems produces a hierarchy in two distinctive senses: (1) The level of emergence is a hierarchically higher level—that is, it has additional, new emergent qualities that cannot be found on the lower level that contains the components. The upper level is a sublation (*Aufhebung* in the Hegelian sense of the term) of the lower level. (2) Self-organization results in an evolutionary hierarchy of different system types; these types are hierarchically ordered in the sense that upper levels are more complex and have additional emergent qualities.

Globalization and localization—Bottom-up emergence means the globalizing sublation of local entities; downward causation means the localization of more global qualities.

Unity in plurality (generality and specificity)—A self-organizing system is characterized by a number of distinctive qualities that distinguish it from other self-organizing systems. Each type of self-organizing system also shares general principles and qualities with all other types of self-organizing systems. Both generality/unity and specificity/plurality are characteristic of self-organizing systems.

The concept of emergence is the central notion of self-organization concepts. Important aspects of emergence are synergism, novelty, irreducibility, unpredictability, coherence/correlation, and historicity. New qualities of a system are due to synergies from the interacting elements of the system. Emergent qualities are qualities that have not been previously observed and have not previously existed in a complex system ("a whole is more than the sum of its parts"). The newly produced qualities are not reducible to, or derivable from, the level of the producing, interacting entities.

Niklas Luhmann introduced the concept of self-referentiality as a sociological application of self-organization theory. In his view, the elements of a social system are self-producing communications, (i.e., a communication produces further communications and hence a social system can reproduce itself as long as there is dynamic communication). For Luhmann, human beings are only sensors in the environment of the system. Luhmann puts forward a functional theory of society that is based on a dualism of system and human actors.

Another type of self-referentiality in social systems has been introduced by considering interpreting the relationship of social structures and social practices and actions as dialectical. Social structures enable and constrain social actions and are produced and reproduced by social actions. This process can be interpreted as a dynamic self-organization process. Social systems are re-creative; they permanently produce and reproduce actions and structures.

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See also Anarchy; Autopoiesis; Complexity; Cooperation; Sociocybernetics; Space; Systems Theory

Further Readings and References

Fuchs, C. (2003). Dialectical philosophy and self-organisation. In V. Arshinov & C. Fuchs (Eds.), *Causality, emergence, self-organisation* (pp. 195–244). Moscow: NIA-Priroda.

Fuchs, C. (2003). The self-organization of matter. *Nature, Society, and Thought, 16*(3), 281–313.

Fuchs, C. (2003). Some implications of Pierre Bourdieu's works for a theory of social self-organization. *European Journal of Social Theory, 6*(4), 387–408.

Fuchs, C. (2003). Structuration theory and social self-organization. *Systemic Practice and Action Research, 16*(2), 133–167.

Luhmann, N. (1984). *Soziale systeme.* Frankfurt, Germany: Suhrkamp.