Triple definition of complexity

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Abstract

Complexity may not be defined or explained with entities and properties. Instead, a system is proposed ontologically, epistemologically, and semantically as the definition or explanation in this paper, with matter, energy and lives as its components, and with all its components defined as changes, which might improve upon our prediction in/with complexity.

Introduction

This paper is written in response to the journal article:

Complex systems in the spotlight: next steps after the 2021 Nobel Prize in Physics (Ginestra Bianconi *et al.* 2023 *J. Phys. Complex.* **4** 010201).

I will try to answer the question of what or how a complex system is, and also Lincoln D. Carr's question, as he writes in this article: "To me that is the ultimate question in complexity—why is it here?"

Including the question—why do we define or explain complexity?

And, it seems that there is only one answer to all these questions, even though we have to express or understand it ontologically, epistemologically, and semantically.

Complexity defined or explained ontologically

Questions about complexity always arise when we cannot explain the behaviors of a whole with its

components, as Adilson E. Motter writes: "… I take a complex system to be a system that (i) is made up of interacting parts and (ii) exhibits dynamical behavior that cannot be inferred from the behavior of the parts themselves.", or as Taha Ysseri writes: "The emergent behavior that is known to be one of the main features of a complex system is when the system's behavior cannot be explained and predicted by solely analyzing the behavior of its parts, in other words, the whole is more than the (linear) sum of the parts."

Ginestra Bianconi defines it in this article: "A complex system is formed by many interacting elements that give rise to emergent phenomena."

Linyuan Lü defines it differently: "Complex systems are formed by many agents interacting with each other in nonlinear ways, …"

But why? Why are the behaviors of the system considered as "emergent phenomena" but the behaviors of its elements not, and why are the elements considered as "agents" but the system itself not? There might still be a trace of what Jacob Biamonte writes in the same article, "… many modern scientists adopt an implicit reductionism-centric view."

It is still our fundamental assumption that the cosmos is an isolated or closed system, composed of elements that never change. The random changes of those elements explain the origins of everything we know. And the system's selection of those changes explains their evolutions. [1, 2]

Really? Has so nonlinear evolution already been explained?

The idea of such a cosmos may be traced back to Parmenides' notion of "one", and such elements to Leucippus or Democritus' notion of ones.

However, as human beings, the only thing we may know is change or relativity. We are not and we may never know such a one or ones, even if they are not the manifestation of our anthropocentrism. Those particles discovered by particle physicists and the cosmos revealed by astrophysicists have not been and may never be proven as the ultimate components or entirety of our reality.

Fermions and bosons, for example, may never explain why they should originate, or even evolve into human beings who always want to define or explain everything.

There is one that is not the one, and there are ones that are not the ones, both of which, I would argue, are together the working language we use to define or explain changes.

There are two kinds of changes defined or explained, either the changes between different ones or the changes of the one itself. The former changes are empirical, and the latter ones are ontological. In other words,

an ontological change is the change of selfness or sameness, not the changes between different selves.

Heraclitus from ancient Ephesus identified two kinds of ontological changes:

- Irreversible change (symbolized below as "C"), as he described: "You cannot step twice into the same river".
- Reciprocal change (symbolized below as "O"), as he described: "Fire lives the death of earth, and air the death of fire; water lives the death of air, earth that of water."

C is the opening of O changes, and O is the closure of a C change. Quantum fluctuation is, for example, a kind of O change, and parity non-conservation in weak interaction or spontaneous symmetry breaking is a C change.

It seems to me that life may then be defined as the oneness, unity, or interdependency of O changes and a C change (symbolized as "OC"). [3] Birth or death marks the beginning or end of such oneness, unity, or interdependence.

$$Life = OC \qquad \text{(Ax. 1)}$$

OC is the third ontological change. In other words, life is both and neither of the other two changes.

The O of OC explains a life's free creation, and the C its determined transcendence. OC is a better explanation of adaptation or reproduction, better than teleology or intelligent design.

Matter may be defined as the O change that is not the O of OC (symbolized as "M"), and energy as the C change that is not the C of OC (symbolized as "E").

Because of the C of OC, all lives are asymmetric or non-conservative changes. The C of OC is not only the open of O changes but also the directionality of the open. Lives may therefore be divided into two categories according to the contrary directions of their C changes. The one with its C toward the E might be called *a spring life*, and the one with its C toward the M *an autumn life*.

A spring life consumes the M and creates the E, and an autumn life does the opposite.

M plus M may be the birth of a spring life, and E plus E may be the birth of an autumn life. The so-called non-living matters, such as protons, neutrons, or atomic nuclei, may all be understood as the remains of some dead autumn lives deeply frozen by the temperature of our environment.

An artificial life, whether hard, soft, or wet [4], is not a life if it is neither a spring life nor an autumn life, or if it is inherently immortal.

As ontological changes, the E, the M, and OC differ from each other only as components of the same system, even though there is no ontological difference between a system and its components.

Complexity = unity of the E, the M, and lives (Ax. 2)

Ax. 2 means that a complex system is a complex system not because it acts as a one or is composed of ones, but only because it is a unity of both paradox and self-consistency.

Ax. 2 means that the M and the E alone may never be the definition or explanation of complex systems. In other words, without OC, the M and the E alone may not be ontological changes, nor compose any complex system.

Even though the M, the E, and both lives determine together all the possibilities of a complex system, lives alone explain the system's robustness and fragility.

Plants and animals are complex systems, but not all complex systems are biological. The possibility that organisms may arise from inanimate matter does not exclude the possibility that all known physical entities may have been created by lives existing before them.

Beings are never the ontological limitation of lives.

Because of the C of OC, it is exclusively autumn lives' mission to create systems or systematic complexity.

Both heterogeneity and natural selection may be understood as the same thing — the O change of OC. Therefore, evolution may never occur without the C of OC, especially the C of autumn lives.

Evolving is the only fundamental nature of all complex systems. Therefore, Stefan Thurner is right as he writes: "If a system is not co-evolving in that sense it remains in the realm traditional physics: finding solutions to equations of motion (or other update rules) under a few fixed forces and initial and boundary conditions—maybe complicated but nothing complex."

Human beings are complex systems dominated by autumn lives, which explains why creating systems has been our main business, and why we explain or define everything in systematic relations.

Complexity defined or explained epistemologically

The E is always the same, and so are both lives. All the distinctions among all the complex systems are only the differences of the M.

The M is the structures, the memories, or the complications of a specific system dominated by autumn lives. The M determines the complication of a system, but not its complexity.

Therefore, a complicated system is not always the same as a complex system. As Cristina Masoller writes: “A large linear system is 'complicated', while a large nonlinear system is complex.” The one defined by Filippo Radicchi in this article, “a system is complex when its behavior is characterized by the superposition of multiple, structural and/or dynamical, scales”, might be complicated but is not a complex system.

All complex systems possess knowledge. Knowledge is nothing more or less than the M. Perception or cognition is the process in which the E is manipulated or interpreted by the M. [(3)]

Ax. 2 determines that no knowledge is possible if without the E, the M, or lives gathered together as components of the same system. The directionality of autumn life determines fundamentally the nature of knowledge, especially our knowledge.

The C of autumn lives also determines the knowledge to be either hereditary or acquired. For example, all the physical or chemical elements in our bodies or brains are our oldest hereditary knowledge.

Every complex system, including its subsystems, may have its own hereditary or acquired memories. Hereditary memory or knowledge determines a system’s hereditary behaviors, and acquired memory or knowledge those acquired behaviors.

Different species may always arise based on different complexity of the M.

Evolution is nothing more or less than the changes of the M. Therefore, knowledge and evolution are one and the same thing. In other words, knowledge is nothing subjective or objective, but only systematic.

The M is always the truth of its system.

For a system dominated by autumn lives, the M is both a unique world and a unique self, as either the birth or the death of lives but never the lives themselves.

No world is ever the world.

No self may ever live.

Complexity defined or explained semantically

Only lives may communicate with each other, and subjects, egos, or selves do not.

The M is the only thing communicated when an autumn life acts as the sender, and the E is the only thing communicated when a spring life does.

Both the E and the M are symmetric or conservative changes, and both lives are dissymmetric or non-conservative changes. An effect may become its cause if in symmetrical or conservative changes, but never in life changes.

A symmetric or conservative change may only be a language since it may not be a cause or an effect. And life changes may only be the semantic meaning since it may not be communicated. Therefore, a language and its meaning may never be one or the same. Their semantic relation may be formulated as:

$$OC = \textit{the meaning of } E \textit{ or } M \qquad \text{(Ax. 3)}$$

Lives are therefore the only cause or effect of all other changes in our brains, bodies, societies, and cosmos.

The E and the M are the only differences between languages. And the nature we experience is a duet of them both.

OC is the only cause or effect of both the predictability and the unpredictability of complex systems. As the predictability, the O of OC is the limitation of the unpredictability, and the C is the directionality of the O.

Because of the C of OC, the probabilistic approach is not enough for us to define or explain complexity. Random variation or stochastic fluctuation only tells us something about the M or the O of OC.

Maxi San Miguel writes: "We need to understand better the limits of predictability (or the meaning of predictability) when dealing with complex systems." I would add that we also need to understand the limits of their unpredictability.

Climate changes are not only the communication between spring lives in the Sun and autumn lives on the Earth, not only how the M of the Earth interprets the E from the Sun, but also how the autumn lives respond to the interpretation, especially with their C change.

Understanding is a life change and knowing is the communication of E or M. Semantically, information or the meaning of communication may only be understood but never known.

Consciousness is the systematic distinction between the M and the E. The reason why there is consciousness is that it may be the birth of autumn lives. In other words, consciousness is the knowing that may lead to understanding. [(3)]

A Turing machine can know or behave intelligently and even consciously, but it may never understand if there is no life as the cause or effect of its activities. Artificial intelligence is meaningful only because there are human lives as its cause or effect.

Language may exist but never live. Ax. 3 means that all languages are equal to each other.

It also means that there is causation but no first cause.

Summary and perspective

Complexity might not be defined or explained with entities and properties. Instead, a system is proposed ontologically, epistemologically and semantically as the definition or the explanation in this paper, with matter, energy and lives as its components, and with all its components defined as changes.

Ginestra Bianconi writes: "… simple models might not capture all the details of complex systems but are our hope to understand and taming complexity…"

At least, I hope, a better understanding of complexity might improve upon our taming of complicated systems.

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