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Mapping degrees of complexity, complicatedness, and emergent complexity

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ABSTRACT

This paper assesses the conceptualizations and analytical uses of complexity. Throughout the paper, we carefully eschew ontological issues, and sort out the epistemology of complexity. We try to explain why the ontology of complexity makes no sense to us, much like significance is neither material nor ontological. Our tool of choice is levels of analysis. First, we analyze the conceptualization of complexity. Much discussion of complexity is confused because complexity is mistaken as a material issue. Complexity arises from the way the situation is addressed, and is not material in itself. Even so, complexity does seem to have material ramifications without being itself a straightforward material distinction. We use an illustrative parallel example where genetic dominance is shown not to be material while having material consequences, but only after a gene is asserted to be dominant on normative criteria. Secondly, the paper compares two analytical approaches based on complexity, namely Robert Rosen's work and Joseph Tainter's work. In Rosennean complexity a system is complex if not all its constituent models are simulable, if certainty is denied. In that sense, complexity cannot be defined. Rosen's distinction is between simple and complex systems makes complexity an all or nothing proposition. Complexification is seen by Tainter as a device used by societies to solve their problems. This leads to complexity being a matter of degree in successive societal complexifications, perhaps from Neolithic hunter-gatherers to industrial societies.

1. Introduction

This paper limits itself to epistemology and remains agnostic as to ontology, which is a separate discourse. Our only reference to ontology is to specify how the epistemology of a situation is separate from ontology, and cannot be directly linked. Ontology is a separate discourse that needs its own terms beyond the scope of the present paper. We work hard to show how epistemology is of limited utility in the realm of ontological assertions. In ecology, ontology is too often used as a direct lever in epistemological discourse. The eminent organismal ecologist, Dick Tracy, once said to Allen that ecosystems and communities are abstractions, but he studies organisms, and at least they are real. Allen even checked back years later, and Tracy confirmed his sentiments. Many would agree with his assertion, but we would not. For us neither ecosystems nor organisms are real independent of abstraction. One of our aims is to sort out the muddles that can occur when epistemological arguments are used to justify directly ontological beliefs. There are good reasons for the tradition of philosophers in keeping epistemology separate from ontology. Even so, ecologists are often willing to rely on what they suppose is the real situation to clench their arguments, particularly with regard to the complexity of an ecological situation. Our concern for complexity carries our epistemological arguments.

Ecologists are challenged by distinctions between complexity and simplicity, and between complexity and complication. Complexity swirls around the interface between materiality and

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abstractions. Materiality is external to the observer while abstraction is created by human observers. Complexity is one of those things that certainly feels real enough and material, while suggesting one cannot quite put their finger on it. Ecologists know complexity when they see it, while sometimes not being able to define it confidently. Some will vehemently insist that complexity is a reflection of materiality in a way that is real; something that is so self-evident it must have a material basis. Others, like us, are much more skeptical.

In this paper we refer to Rosen's work on complexity to come down on one side or the other for the origins of complexity. Rosen starts his discussion of complexity from the basic duality between the self and everything else (1991). One can experience the self, but everything else, or what Rosen calls the "external world" (1991: 41), is not directly accessible. According to Rosen, one's understanding of the external world is based on modelling. Modelling consists of establishing congruence between one's entailment system and the external world. Entailment invokes a loop of logical consistency surrounding the model, "if, if, if, then." Rosen invokes a causal loop of entailment in the functioning of the observed. He works with observables not reality. A modelling relation is established when "we have brought at least a part of the inferential machinery . . . into congruence with a corresponding part of the [observed system]" (1991: 54). Complexity arises when a system does not match the predictions of the formal model used to describe it. A simple system is one that can be correctly predicted by a model. A complex system is one which cannot be fully simulated, or computed, using models. In Rosen's words, a complex system "must have a nonsimulable model" (Rosen, 2000: 292). Complexity would "require, at best, an infinite number of distinct formalizations to capture all the qualities" (Rosen, 1991: 9) missed by the entailment system of computable models.

Complexity is thus a relational property, derived from the comparison between the observed system and its model. Rosennean complexity is an epistemological issue, not a property of the external world. Nevertheless, complexity has material consequences. In his study of complex societies, Tainter argues that complexity is used as a problem-solving strategy, so that societies evolve from less to more complex. The purpose of this paper is to assess the implications of Rosennean complexity for ecology, and for the study of complex systems.

First, we assess the implications of Rosen's epistemological definition of complexity with respect to material difference. The possibility of the materiality of complexity stands as the basis of the analysis of complex systems, a central concept in ecology. Second, we compare Rosen's and Tainter's assessment of complexity with regard to the concept of emergence and the possibility of degrees of complexity. Third, we distinguish between complexity and complicatedness to draw attention to the potentially confounding interaction between abstraction required to deal with the material world and the material world itself.

2. Material difference

One way to narrow things down is to look at a simple system and, with all else equal, seek its complex counterpart, for comparison. As an explanatory example we use the conversion of a merely complicated version of an army on the move and compare that to its complex battle-ready condition.

For our military example, Rick Atkinson (Atkinson, 1943) reports on the Allied Expeditionary Force in WWII in 1942 as it left North America sailing for North Africa near Casablanca. The ships were loaded with regard to sailing across the Atlantic. Batteries were loaded deep in the hold because they were heavy, so that they could serve as ballast. So the loading did have some order to it, but that had little to do with criteria for efficient unloading while facing resistance to the landing. The model for the simple system might take the form of the position of all the bits of materiel on the boats. Such a model is complicated but distinctly possible. There were many degrees of freedom as to where what military equipment was put on the ships. The functioning of the invading force as such was not much of a consideration, beyond having all the pertinent materiel on board somewhere. In a sense the loaded ships were largely unorganized. That would make the system only complicated; that is an elaborate version of simple, but still simple. Guns and ammunition were not loaded near each other, and gun sites were loaded somewhere else. Medical supplies, important as casualties mount in the beach landings, were not loaded so they could be readily unloaded early in disembarkation.

To achieve invasion the materiel had to be organized. This amounted to converting a complicated only simple system into one that became complex. It took days for the gunners, the ammunition, the guns and the gun sites to be all in one place. Only over time did the complicated system of loaded boats become organized into a complex fighting system. The difference in this case was organization. Degrees of freedom were removed as the parts of functioning guns were constrained to be together in space.

The organized invading force consisted of the same materiel, that is to say material, as the unorganized loaded boats. The difference is the elaborate constraints on the parts for a challenging task. So while the constraints have material consequences as to space and material, the complexity is more conceptual and less physical. So complexity appears in a dance with the material system, but is not exactly material itself. The complicated and complex versions of the army consist of largely the same material parts, so no difference there. That denies most of the case for the difference between complicated and complex being directly material. Complexity in this case was achieved by organizing the parts in relation to each other, by imposing constraints and denying the parts degrees of freedom. In the historical army, that did move the material parts this way and that, but the complexity itself was embodied in a plan and its purpose, not material complexity, whatever that might be. That plan invokes Aristotle's formal cause not his material cause.

Complexity appears to relate to purpose and function. The purpose in question in the army example is clear, it is the purpose of battle, but sometimes it can be purpose coming from the observer understanding the situation. In an ecological example, that purpose may be something like the reason for leaves being flat to facilitate photosynthesis. The leaves are not sitting there scheming, and evolution did not aim; the purpose is found in the observer seeking an explanation for the form of foliage. Organization is focused so that complexity appears or disappears as the focus of the story-teller is changed. Notice that the batteries loaded as ballast is a matter of organization to a degree, just not the same degree as in the emergent complexity facilitating the invasion. Complexity emerges by crossing a threshold in the context of a function.

Certainly some aspects of complexity appear quite concrete, but the hook is that the concrete arises only after some decision has been made or some situation is named and determined. The ease with which abstraction may be mistaken for something material can be shown by the concept of dominant and recessive genes. The error in understanding dominance as concrete is almost universal.

Almost all biologists would come down on the material side for genetic dominance. Dominant genes have material consequences as a result of the mechanics of protein synthesis. Dominance is expressed as material observed characters in the organism which overcome any recessive character also in the genome. The gene codes for a protein, the consequence of which is a biochemical species that causes the dominant character to be expressed. Surely

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