

# Complexity: A Philosopher's Reflections

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## COMPLEXITY: A PHILOSOPHER'S REFLECTIONS

All Nature is but Art, unknown to thee;  
All Chance, Direction, which thou canst not see;  
All Discord, Harmony not understood.

Alexander Pope  
Essays on Man 1733

### I

Over the last decade or so, much has been written about the new "science of complexity". From journalistic hyperbole to cutting edge research, it is widely assumed that the science of complexity has indeed discovered something new, that is worthy of the attention of scientists and philosophers alike. But what? An overarching principle that connects the study of complex systems across the physical, biological, and social sciences? A method of discovering how order emerges at the edge of chaos? A way to understand phenomena as diverse as the crash of the stock market and the extinction of a species? Of course, there is internal disagreement amongst those who do work on complex systems about how they view their discipline, reflecting varying degrees of optimism and skepticism about any potential unification that the study of complex systems might be able to achieve.<sup>1</sup> Yet lost in the din has been the framing of several basic philosophical questions, without which a serious understanding of the value of complexity theory cannot proceed.

Is complexity theory based on claims that are fundamentally epistemological or ontological in nature? Is the debate now going on in the science of complexity merely the old one about indeterminism versus hidden variables, already familiar to us from quantum mechanics? That is, is complexity an artifact of the world or of our understanding of the world? What difference does it make? Is complexity real or only a function of our limited understanding? Indeed, what sort of ontology is consistent with the assumptions made by complexity theorists? Are we required to give up determinism? Is complexity merely a practical problem of our understanding, even if a deep one?

It has long been a truism of the philosophy of science that good philosophical work cannot be done unless it is informed by ongoing science. Similarly, one might here pronounce that good scientific work should be informed by philosophy. With that in mind, I shall try here to raise several philosophical issues that seem to have been

overlooked in the debate about the science of complexity.

## II

At base, the study of complexity concerns those systems that allegedly cannot be understood when using a linear, reductionist approach. As opposed to the traditional focus of science on simple, static systems, where the outcome of the whole is merely the aggregate of the behavior of its separable parts, the science of complexity purports to study those systems exhibiting dynamic interaction between many independent variables, leading to emergent order. The interaction between the parts of a complex system is taken to create something new—an order that is not explicable in terms of the individual behavior of its separate parts—that must be studied at a level of description at which the complexity of the system is preserved. Thus the order found in a complex system is taken to disappear in attempts to simplify or reduce it. Instead the order discovered by complexity theorists is alleged to be truly "emergent" in that it integrally depends on the use of a level of description to capture the behavior of the system that does not obscure the complexity that is behind it. In short, a complex system is one that must be understood at a level of description at which the order we wish to have explained is not obscured by our efforts to comprehend it.

Thus, a central idea behind complexity theory is that there are limits to our knowledge of some systems, even though they are ordered, because we must study this order only at a level of inquiry at which the complexity of the system is ineliminable. But what kind of limits we are talking about here? Are they limits on us? On our cognitive abilities to process and understand certain sorts of information? Or are they supposed to be limits on nature, where we are maintaining that complex systems are somehow different in kind from simple ones? It is here that I would like to introduce a basic philosophical distinction that seems important in understanding what complexity theory is all about.

In their work on questions from ethics to metaphysics to aesthetics, philosophers have drawn a sharp distinction between matters of ontology and matters of epistemology. Ontological issues are matters of existence or being. Ontology is the study of the fundamental nature of reality--the world in itself. Such issues are separate from our knowledge of reality, and are concerned only with the state of reality as it exists independent from us. Does God exist? Is the moon made of green cheese? Is there intelligent life outside our Solar System? These are ontological questions. Ontological limits are those imposed by reality itself.

Epistemological issues are matters of our knowledge of reality. Yes, the world may be in a certain state, but how can we know that it is--that is the realm of epistemology. Epistemological limits are those imposed by our cognitive abilities, our sensory limitations, our inability to check some facts firsthand, etc. In general, epistemological limits are those that arise as a function of our inability to know the world.

This distinction between ontology and epistemology is absolutely fundamental to philosophy. Philosophers think a lot about limits to our understanding of things. But, of

course, the question always arises, "are these limits to our understanding a function of the way that the world is or a function of our limitations in understanding the way that the world is?" Would the material world actually exist if humans were not here to observe it? (this is an ontological question). Could I know that it exists? (this is an epistemological question). Is there an odorless, colorless, weightless gas that permeates the universe and holds up light beams called "ether"? (this is an ontological question). Could I detect its existence? (this is an epistemological question).

I have tried here to offer some straightforward examples, to give one a feel for this as a working distinction. It is nonetheless true, however, that it is often quite difficult to know when we are reaching a limit whether it is ontological or epistemological--whether it is an artifact of some heretofore unimagined blip in reality, or only an artifact of our imperfect understanding of reality. It is nonetheless my belief that one cannot get very far in deciding fundamental questions about the nature of complex systems unless one has thought about this distinction.

Are complex systems "really" complex? That is, are they complex "as such" given some feature of reality? Or do certain systems only seem complex to us because of our limited ability to understand them fully, in somewhat the way that the heavens "seemed" complex to us before Newton showed us that they could be described by relatively simple laws? Is Alexander Pope right that "disorder is order misunderstood"? Is complexity merely an artifact of our limited point of view? In short, is "complexity" a matter of ontology or epistemology? Is the limitation in our understanding of complex systems a function of the systems or of us?

Failure to distinguish sharply between these two issues-- indeed to ignore the distinction entirely--is quite common throughout the natural and social sciences, and predates modern work on "complexity theory" by many decades. Perhaps the best example in the social sciences is the work of F. A. Hayek, who argued 50 years ago that there was a fundamental break in the methodology of explanation between the natural and the social sciences, due to the prohibitive "complexity" of the subject matter of social science.<sup>2</sup> Hayek's view was echoed by Michael Scriven and many others in the field, and even today serves as one of the most common arguments against the possibility of a science of human behavior, purporting to rule out social scientific laws and predictions, on an a priori basis. (Indeed, in Stephen J. Gould's hands complexity also serves as an argument against laws and predictions in evolutionary biology as well).<sup>3</sup>

In a recent book, Laws and Explanation in the Social Sciences, I have defended the existence of laws in the social sciences, and consequently the prospects for a science of human behavior.<sup>4</sup> In doing so, I have been forced to answer the charge that human behavior is "too complex" to have a science of it. My conclusion is that the claim that human behavior is too complex to be studied scientifically is dead wrong--though in an interesting way--and that at base it relies on a subtle ambiguity in what one means by "complexity". This ambiguity, I believe, has led to a lot of muddled thinking about the alleged limitations of scientific explanation when faced with a complex subject matter. It

will not surprise you to learn at this point that the ambiguity I am speaking of here is that between the ontological interpretation of complexity and the epistemological interpretation of complexity. Let us consider both possibilities.

When Hayek argues that the subject matter of human behavior is too complex to support a true social science, what could he mean? Could he mean that the complexity of human phenomena is absolute? That it is a feature of the social world "as such"? That it is a function of the ontology of human interaction? This interpretation is problematic. For, if this is the claim, one must be quite specific about what it is about human systems that, no matter what theory we use, they will always be prohibitively complex.

Ontological commitments are not cheap. Is Hayek committing us to some sort of "supernaturalism" or the existence of divine causal forces that are behind human behavior? Is he committing us to "indeterminism" at the social or cognitive level, on par with indeterminism at the subatomic level, through some sort of hierarchy of material dependence? If so, much more would need to be said about how particle physics somehow connects with human free will. If this problem has already been solved, I am not aware of it. At the very least, anyone who supports the idea that complexity is an ontological matter owes us a proof showing that, even if they do not presently know the exact chain of causal dependence, there could be no "hidden variables" behind human behavior that could be making it seem as if there is a breakdown in determinism at the social level, when in fact it just may be a breakdown in our understanding of it. In short, if one hopes to make a success of the ontological interpretation of complexity, one should recognize that the cost will be high; for the plausibility of this account will depend on the credibility of a promissory note that there is indeed some glitch in reality at work--such as indeterminism--necessary to make the ontological interpretation worthwhile.

Better, I contend, is to accept the idea that complexity is an "epistemological" matter. According to this view, human systems are not "inherently" complex. They are not complex "as such" but only as described and defined by a given level of inquiry. What is the nature of our interest in human behavior? What sort of questions do we ask about it? That is what will determine the level of complexity that we are dealing with when we seek to understand certain features of human interaction. For the subject matter of social science is not a "natural kind" just sitting out there waiting for us to discover it. A subject matter is created only when we begin to ask questions about the features of reality that are puzzling to us. Thus, on this interpretation, complexity is derivative rather than inherent. Complexity exists not merely as a feature of the world, but as a feature of our attempts to understand the world. Complexity, in short, is inextricably bound up with your point of view.<sup>5</sup>

This would mean, however, that there is no "fundamental" limit to our understanding of "complex" systems. For on the epistemological interpretation complexity can always be overcome. Indeed, once one realizes that complexity is an artifact of our understanding of the world, the goal would be to show that Pope was right--that disorder is in some sense just order misunderstood--that complex systems can be made simple.

Here's how.

Once one accepts that complex systems are only complex "as described", there is always the possibility that some alternative description--some "redescription"--of the system will yield regularities that are simpler, and can be handled by science. If there is order behind complex systems, and if complexity is remediable by alternative descriptions, doesn't it follow that some redescriptions will make that order apparent while other will not? The job of science, then, is to search for those descriptions of the phenomena that will unlock the regularities that are behind the surface noise of complexity. Once we have abandoned the ontological interpretation of complexity, we have liberated ourselves from the necessity of figuring out how the study of complex systems jibes with the more conventional view of scientific understanding as the search for order. For redescription is at work in all scientific understanding, as we search for those theories that yield better explanations of the order behind surface diversity, whether we choose to label them as "complex" or not. The goal, that is, is to realize that the method one uses to study complex systems is not really that different from that which we are using all of the time science, whereby we search for order through using redescriptions.

This is not to say that we should attempt to create order where there is none. Neither is it to deny that there is a reality out there, that supports certain descriptions but not others. It is to realize that in attempting to understand reality we have many descriptive tools at our disposal, and may find that certain phenomena appear to us to be prohibitively complex only because we are too locked in to inefficacious descriptions of nature. So even while we should recognize the real danger presented by the prospect of producing only "naïve correlations" with our redescriptions, we should also realize that redescription, when used properly, is a powerful method of breaking the hegemony of a given vocabulary in our search for order.

### III

At this point I would like to introduce the second philosophical idea that seems relevant to the study of complex systems. It is the idea of "non-reductive materialism". This idea grows out of the perennial debate in the philosophy of mind over how is it that something like "the mind" can be fundamentally materially dependent upon "the brain", and yet one cannot fully understand the mind in terms of the brain. This is the old problem of emergentism and reductionism, and philosophers have spent a good deal of effort trying to figure out how they can admit the fundamental ontological dependence of phenomena at the "higher" or "secondary" level of organization on those at the "lower" or "primary" level without sanctioning reductive explanation. How can one preserve the idea that the mind depends on the brain, without sanctioning the belief that the mind is fully explained by the brain? How does one preserve the autonomy of explanation at the secondary level--in recognition of the "emergence" of certain regularities that do not seem to be adequately captured at the primary level--without violating material dependence?

The breakthrough idea here again involves recognition of the importance of the

distinction between ontology and epistemology. For one does not need any sort of ontological break to support the epistemological emergence of phenomena at the secondary level. Let me explain what I mean. The apparent conflict in supporting material causal dependence between secondary phenomena like "the mind" and primary phenomena like "the brain", and still wanting to maintain non-reductive autonomous explanations of secondary phenomena, is dissolved once one realizes that "emergence", like "complexity", is an epistemological concept. One does not need to support any non-standard ontological assumptions involving supernaturalism or divine causes in order to get it. One need not even violate deterministic causation. All one needs to do is admit that the emergence of certain regularities is a function of our descriptions of them, and thus see that they ought to be explained in their own terms without violating any of our assumptions about nature itself. "Complexity", "Emergence", "Simplicity", "Order", "Disorder", and so on are epistemological concepts. They are relative to our descriptions of reality. Thus, they apply to any given phenomena only contingent upon our use of a particular descriptive framework.

Certain regularities will emerge given one descriptive framework that will not emerge given others. Some phenomena will appear to be complex given one vocabulary that will not with others. Some systems will seem ordered given a particular way of thinking about them that will seem disordered given others. Order depends on our description. We here see that the recognition that complexity is relative to a particular level of description liberates our understanding of what sorts of explanations are legitimately scientific. For we now may have all of the emergence and explanatory autonomy we want, without having to resort to "supernaturalism" or other odious ontological assumptions.

The philosophical idea behind this is as follows: there may be one world, but there are an infinite number of alternative ways of describing it. And since explanation itself depends upon our descriptions, there are potentially an infinite number of explanations of any given feature of the world. Our knowledge of the world is necessarily filtered through our language--through our descriptions of reality. So even if what we are trying to explain is the world, we can do so only by employing descriptions. This is not to argue that any old descriptions will do. Nature rules out infinitely many descriptions that are inconsistent with it, even while there are still always an infinite number ruled in that are left to do the job. We must make sure that our descriptions do justice to reality. And yet we must also realize that the descriptive apparatus we choose to capture reality is in some sense arbitrary in that there are many alternatives. Of course, some will be more efficacious than others. Some will make the world seem simpler. It is those that we seek in scientific explanation.

Thus, our acceptance of the idea that complexity is an epistemological matter helps us to contend with it, through the use of alternative descriptions of reality, that may reveal the fundamental order behind "complex" systems, by rendering them simpler. Yet we eschew reductive explanation here--even while embracing materialist (ontological) dependence--because we now realize that reductive explanations too must depend on

descriptions. And, absent access to God's Adamic language, how can one presume that the vocabulary one has chosen is the correct one? Autonomous explanation of epistemologically emergent regularities is to be preserved. Indeed, there may be many different levels of explanation of any given thing. In understanding complex phenomena, we need all of the help we can get.

Complexity, thus, is best understood as an artifact of our descriptions of reality, and not strictly speaking as a feature of reality itself. Yet, in saying this, it is important to be clear that I am not intending to underestimate the difficulties that complexity can provide for us, nor am I claiming that complexity is not sometimes a very real barrier to our scientific understanding. In what sense, then, should we think of complexity as being "real"? I think it is defensible for one to contend that complexity is "real", even upon the epistemological interpretation of it, given the claim that one cannot understand certain phenomena without using a level of description at which complexity is preserved. Complex systems can only be understood as complex systems; to do less--to attempt to reduce them to their component parts--is to miss their explanation. Yet, to claim that complex systems can only be explained as complex is to say something very different than that they really are complex.

But then may we ever legitimately say that a system "really" is complex? This is a matter of mere semantic preference. What I am arguing against, however, is the error of inflating such a semantic preference into a metaphysical commitment, as if the only way that one could support the epistemological virtues of complexity theory as an explanatory enterprise would be to give complexity some spurious ontological status. But this, I contend, we should not do. No matter how we may choose to express ourselves for the purposes of our understanding, we should be wary of the dubious ontological assumptions that may lurk behind our language. For just as it is important not to underestimate complexity, neither should one overlook the important philosophical issues that it raises.

#### IV

In this section I shall examine an example of an ongoing research problem in complexity theory, in order to show how the philosophical ideas brought up so far in this paper might find purchase in actual scientific research. My aim here is not to show that paying attention to philosophical distinctions can itself solve scientific disputes, but rather that attention to philosophical matters can clarify what is at issue, and help to define the proper domain of empirical inquiry. Thus, I hope here to make a connection between philosophy and the scientific study of complexity by demonstrating how the philosophical ideas of (1) the distinction between ontology and epistemology, and (2) the concept of non-reductive materialism, might be played out in one example of ongoing research within the science of complexity.

The example I have chosen is that of a non-aggregate, dynamic, secondary phenomenon, in which the behavior to be studied is a result of local interactions that



result in global patterns that cannot be understood by attempting to reduce them to their component parts. The behavior is, nonetheless, perfectly dependent upon these local interactions. Thus, it seems clear that the paradigm of complexity is an appropriate one for attempting to understand it. What I hope to show also, however, is that in the example I have chosen one would be mistaken in thinking that the secondary phenomenon had any special ontological status. Here the existence of a pattern depends crucially on our level of description, and we appropriately seek explanation at a level at which complexity is apparent. But what I hope to demonstrate is that it would be philosophically spurious and scientifically misleading to take it as a "separately existing entity".

The example I have chosen is the fascinating problem of the "traffic jam out of nowhere". Following Rudi Keller, we may describe the problem as follows: let us assume that we have a heavy density of cars travelling smoothly at 60 mph on a single lane highway. Suddenly one driver brakes, slowing to 50 mph. Let us call this driver "A" and the following ones "B", "C", and so on. Seeing A's brakelights, driver B will brake too. Not knowing how rapidly A has decelerated B will brake too much rather than too little, to leave an extra margin of safety. Suppose, therefore, that B slows to 45 mph. The driver behind B will have a similar problem, and will slow, say, to 40 mph. After a repetition of this chain of reasoning as it travels down the line, we may suppose that driver K, and all of the drivers behind, will have to stop all together. We thus find a situation in which each driver's individual decision that it is "better to brake too much rather than too little", based on their intention not to bump into the car in front of them, has led to a global pattern that, although they have created it, they do not understand how it came about: the traffic jam out of nowhere.<sup>6</sup>

This example seems an appropriate one to consider from the point of view of complexity theory. It concerns the emergence of an ordered secondary phenomena which, while perfectly determined by the local interaction of its component parts, cannot be understood as a pattern except from a more global perspective. It is, moreover, non-aggregate, in that its existence as a pattern depends on dynamic interaction between the parts. In order to explain it, therefore, we need to do more than attempt to reduce the problem to an understanding of the general attitudes or principles that are guiding the individual decisions of each driver. For it is not immediately apparent how the "traffic jam out of nowhere" can be accounted for merely by citing the intention of each driver not to bump into the car in front of him. It is, in this respect, a secondary phenomenon that may appropriately be considered a candidate for study by the science of complexity.<sup>7</sup>

What I hope now to demonstrate is that this example also highlights the important role that philosophy can play in helping us to come to grips with the scientific explanation of such a phenomenon. First, let us consider the philosopher's distinction between ontology and epistemology. Clearly, the empirical problems at hand in the study of complexity are enough to occupy the attention of the scientists and engineers who are studying the problem of traffic, without suggesting that they should be distracted at every turn with consideration of the distinction between ontology and epistemology. And yet, I

submit that it is important to understand, as Hayek and others did not, that the phenomenon we are dealing with here is complex "as described" and not "as such".

But what does this mean, especially in light of our realization that some phenomena can only be explained at a level at which complexity is irreducible? What I am suggesting is that there is virtue in scientists taking seriously the philosophical distinction at hand, in order to avoid the error of supposing that a problem like the "traffic jam out of nowhere" is something more than just the deterministic result of the individual decisions of each of the drivers. For if it is not—if one supposes that the complexity exhibited is ontologically "real", and not simply a function of our level of description of the problem—we have opened the door to the criticism that our scientific understanding of it must therefore be "supernatural" or otherwise metaphysically mysterious. There may be a legitimate sense in which we find it explanatory to speak of the "wave of traffic flow" or the "mood of the crowd" as being more than just the sum of its parts. But, if we insist on interpreting this commitment ontologically, rather than epistemically, we risk the impertinent observation that it therefore must depend upon causal factors arising from some domain other than the material circumstances upon which it was taken to be perfectly dependent! My point here is that we should allow our explanations the freedom to describe the phenomena under observation in whatever way seems most efficacious. But, one must nonetheless be careful of taking the metaphorical or theoretical elements of our descriptions too seriously, lest we begin to think of them as multiplying those entities that are ontologically genuine, thus infecting our explanations with a dubious metaphysical worldview.

The perspective of "non-reductive materialism" may here be seen as providing a more appropriate framework within which one may make clear what is philosophically at issue in the explanation of something like traffic. For what causes the "traffic jam out of nowhere"? Nothing more than the individual intentions, decisions and behavior of the drivers of each individual vehicle. In this sense the traffic jam is "materially dependent" upon the drivers in the same way that the "mind" is materially dependent upon the "brain". The state of the system at the primary level is perfectly causally sufficient for the behavior that we observe at the secondary level.

But how might we explain the phenomena at the secondary level? Here is where the fruit of non-reductive materialism may be appreciated as perfectly consistent with the kind of explanatory accounts that we wish to give within the science of complexity. For in the case of the traffic jam, as with the explanation of our mental experience, we soon realize that in order to understand the behavior that emerges at the secondary level of description, we cannot simply reduce it to the primary level. Something would be lost—indeed the pattern we hope to account for may cease to be a pattern—at the primary level of description. Thus, in our explanations we should feel free to introduce new descriptive categorizations at the secondary level, in order to further our understanding of the phenomena under inquiry, even while understanding that the new concepts we are creating must not be unwittingly accepted as ontologically genuine, else they may violate our commitment to material dependence. In short, we may legitimately pursue autonomous

explanations of secondary phenomena, while yet admitting that they are perfectly materially dependent upon relationships at the primary level.

The complete understanding and explanation of the traffic jam out of nowhere therefore may justifiably make use of concepts and metaphors that have no meaning at the primary level of description. But we tolerate them, just as we do in the study of mental experience, due to their explanatory efficacy. Thus, non-reductive materialism may, in the study of traffic jams, as well as in other areas of inquiry within the science of complexity, outline a useful way in which to understand the unstated philosophical assumptions that stand behind our scientific explanations.

## V

It is my hope that these two philosophical ideas: the distinction between ontology and epistemology, and the idea of non-reductive materialism, if taken seriously, will have important consequences for the study of complex systems. Let me end by sketching out the beneficial consequences which the above ideas have had in my own work, on the problem of unification of the methodology of explanation across the natural and social sciences, despite the allegedly prohibitive complexity of human behavior. Can we have laws in the social sciences? Can we predict human action? Should the method of explanation in sociology emulate that in physics? My answer to each of these questions, based on the ideas sketched above, is yes.

Now obviously there are some differences in the subject matters of natural and social science. And yet unification of the method of inquiry used is possible. For on my view the set of problems faced by scientific explanation in physics, anthropology, economics, and biology are all basically the same. We are all dealing with phenomena that at some level are complex. And we are all in search of explanations that will reveal an underlying order.

Historically, most social scientists have failed to see this because they have embraced a highly idealized 19th century standard of linearity that purportedly was met throughout the natural sciences. We now know that this picture isn't quite accurate. Indeed to emulate such an outdated ideal of natural science is to miss the point of much modern work in complexity theory. For surely it is naive to claim that all of natural science is simple. Consequently, many contemporary social scientists have met the idea of complexity by rejoicing! Now that natural science has been brought low, they surmise, unified method looks possible because we have brought natural science down to where social science has always been.

But no. That is not the right attitude to have. It's just that we now have a more sophisticated view of science, where we can see that all scientific explanation is about the use of redescriptions to search for the regularity that underlies surface diversity, whether the system is labelled "complex" or not. Of course regularity may elude us in systems that initially present to us as complex. We must unlock these systems with the use of the

proper descriptions. Wherever we can, we must rely on the use of redescriptions to overcome complexity, whether it be physical, biological, or social, so that we may understand the order that is behind it. For we must realize that it is this search for the order that is behind complexity—this recognition that disorder really is order misunderstood—that is what all scientific explanation is really about.

#### NOTES

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1. It is for this reason that some have objected to the use of the term "complexity theory", for its implication that we already have in hand such a unifying theory. I shall use this phrase below not to beg the question against this debate, but only to serve as a shortened way of referring to the "science of complex systems".

2. F. A. Hayek, "The Theory of Complex Phenomena", Studies in Philosophy, Politics, and Economics (Chicago: University of Chicago Press, 1967), pp. 22-42.

3. Stephen J. Gould, "Dollo on Dollo's Law: Irreversibility and the Status of Evolutionary Laws", Journal of the History of Biology, Vol. 3, #2 (1970), pp. 189-212.

4. (Boulder, Colo.: Westview Press, 1996).

5. This is to say also that order is created by complexity only from a point of view. The underlying material relationships that support order have always been there, but they must be recognized as order by someone. Order must be unlocked by the use of the proper descriptive terms. Order too, then, is epistemological.

6. Rudi Keller, On Language Change: The Invisible Hand in Language (London: Routledge, 1994), p. 63.

7. Indeed the problem of traffic flow is currently the subject of a \$25 million study at Los Alamos National Laboratories.

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