Editorial (13.4)

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Introduction

Complexity came out of the natural sciences when (at last) physics came to consider the behavior of open systems—that is systems that were open to flows of matter and energy. Some such systems were found to exhibit self-organizing behaviors where structure and organization could arise spontaneously over time. So, chemical systems such as the Brusselator, with feedback reactions between the components, demonstrated that, providing they were kept out of chemical equilibrium by feeding the reaction and taking out waste products, all kinds of spatial and temporal patterns could be generated. And this turned out to be one of the door openers to the whole of Complexity Science.

But a recent interdisciplinary workshop I attended made me ponder the importance of complexity for social science. One message is that societies, social situations and organizations are unique, each with its history, structures and culture, so that repeatable experiments, or the consideration of an ensemble of similar systems—the methods that underlie the natural sciences—are inapplicable. This suggests that we shall not find the generic, universal and general ‘laws of social science’ that will be equivalent in power to, for example, Newton’s laws of motion.

However, we can transfer the kind of ‘mathematics’ that was used to study the Brusselator—chemical kinetics—to social systems. The mathematics describes the changes in the concentrations of different types of chemical molecules over time and space where the feedbacks between the reactions lead to nonlinear dynamical equations. The equations arise from an ‘accounting’ exercise that calculates the change in each molecular population as a result of the ongoing chemical reactions, and of its diffusion in and out of the location. And this was how the ideas of self-organization within physical systems were understood and modelled in these relatively simple physical systems. Together with similar work in hydrodynamics, lasers and other physical systems they gave rise eventually to the revolution in scientific thought that we now call ‘Complexity Science’.

Moving one step closer to social systems, this chemical kinetics was just ‘population dynamics’ for molecules. Exactly the same mathematics could be used in describing the patterns of growth or decline of biological populations that were interacting—possibly competing for food or eating each other in various metabolic chains. So, ecosystems might be thought to be structured and organized in a similar, though much more complex, way to the Brusselator—its dynamic patterns of populations could perhaps be understood in terms of the births, deaths and spatial movements of different types of population. If this were so, then it would have led directly to computer models of ecosystems that would have allowed them to be ‘managed’ (e.g., fished, hunted, made stable, etc.) for the benefit of humans. But it turned out that such simple, mechanical, representations of ecosystems were inadequate since the simple mechanical models calibrated on a real system were unstable and collapsed down to a few simple metabolic chains, while the *real* ecosystem did nothing of the kind—remaining complex, diverse and mysteriously opaque to would-be analysts. The point was that in describing an ecosystem as the interconnected population dynamics of different species, it overlooked the internal diversity within each population, using as a descriptor an ‘average’ individual. So, in such simple models if a particular population had more deaths than births then it would simply continue to decrease until extinction. But, in the real world each population was actually made up of different ages, different colors, different characters, spatially distributed within the system. In which case, whenever interactions resulting in deaths became stronger than births, it would *first* affect those with the most vulnerable characteristics, and in the wrong place. As these unlucky individuals were ‘harvested’ by some predator, say, the death rate of the population as a whole would decrease as the less vulnerable types increased as a proportion of the population. And this means that every single population ‘named’ by the modeler, actually possessed a ‘self-correcting’ power to fight off both excessive vulnerabilities or excessive success in the interactions with other populations, which resided in its internal diversity and heterogeneity. So the existence and persistence of ecosystems could not be understood in terms of the interactions at the scale of whole (averaged) populations, but instead relied on the lower level of description constituted by the internal diversities and heterogeneities of those populations. It is this multi-level structure that constitutes and gives persistence to ecosystems. Ecosystems are the result of a multi-level coevolution between species, heterogeneous populations of individuals and within individuals with different possible behavioral responses and group behaviors.

So, at the level of populations we find that it is the diversity that lies within them that turns out to be crucial in their long term existence. Similarly, within individuals, if there are portfolios of possible behavioral rules that can be tried out, then this leads to a further internal level of diversity that does not require the physical elimination of the vulnerable in order to triumph. The adoption of new ideas and behavioral rules that ‘work better’ can be much faster and lower cost than having to wait for births and deaths to allow change.

And so we have arrived at social systems. While simple molecules can be relied upon to always do the same thing in the same circumstances, rarely getting bored and having little sense of humour, evolved organisms—particularly people—have internal representations of their world that are constantly being modified by their experiences. Their ‘behavioral rules’ are therefore potentially in permanent evolution as a result of multiple surprises and disappointments and stabilized only by comforting successes. Of course, in a somewhat unpredictable, changing and even random world both the negative and positive inferences concerning the performance of current behavioral rules may be incorrect, but nevertheless this is all we can do. The world of social science is a world of permanent ‘becoming’ as the very elements that compose it evolve and change, as they explore new behaviors themselves and reflect back the changing behaviors and ideas of others around them. In this flux we can try to learn—but will inevitably fall short of clear understanding as the nature of reality continues to evolve and change. And the while our understanding may appear to reach some stable set of components for a time, over time reality will surpass any such stable view.

Why is this so?

This is because our world is one in which ‘emergence’ occurs. So, some new behavior or interaction that the multi-level coevolutionary process may create, can lead to new properties, new features and new dimensions (symmetry breaking) that emerge in the system. For a modeler, this means that new variables, new parameters, new mechanisms can occur over time which can not only modify the answers we will find to our questions, but will modify the questions that we are asking. So, in addition to the failure of our mechanical models and representations because of internal diversity and richness of reality, systems, populations, individual elements and their constituent parts can also exhibit emergent qualitative changes. In order to understand this let us use a simple example of Origami. I can take a two-dimensional sheet of paper and after a few folds can make a vase, a horse, a hat, a flapping bird, each of which has different emergent features with emergent functionalities (see Figure 1).

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https://journal.emergentpublications.com/wp-content/uploads/2015/11/a29aa012-0f9c-e7c1-6c4f-4a3aa11116c0.png

Fig. 1: Evolutionary origami

The common feature to all of these is the paper—which has not changed. But all the important properties, all the things that matter are about the emergent dimensions of wings, capacity, beauty, etc. and these are not answerable from the physics of the paper. As new folds are made there is a morphogenesis, although it is unclear at what precise point a wing, leg or head has emerged, because we will tend to do this retrospectively when we see that we have formed a bird or a horse. Just so in real life we can only label new things and understand new functionalities after they have occurred. Folding the paper has led to an emergent level of description, an emergent world with possible interactions and feedbacks between things that have no meaning for the paper. The 'dynamics' of the paper-folding matters because the emergent object and its features will depend not only on *which* folds are made, but in what order they occur. While the paper may be indifferent to the different things that have been produced, if the supply of paper for different streams of production is dependent on the choices of an 'agent' then the views and values of the agent will decide which shapes flourish and which become extinct.

So, social systems of interacting, exploring, reacting agents who are trying to learn, although they may be able to adapt their interpretive frameworks to the things that have emerged in the past, they cannot know what will emerge in the future, what new dimensions will be engaged, and indeed what is really happening. This is why interpretive frameworks (models) must always be seen as a temporary, current view that will be subject to revision over time. Complexity turns out then not just to imply a difficulty in clarifying the complication of things, but the fundamental impossibility of fixing our understanding in an evolving universe. Nevertheless, we have to look for local problems, and ideas which our current interpretive framework leads us to believe can be 'helped' by taking one course rather than another. Our striving to understand a little better some issue or element we encounter is all part of our struggle to survive and prosper in the universe. This understanding of complexity tells us that we shall never be bored, never have 'cracked it', and will continue to find challenges and puzzles to keep us busy for as long as we survive.