A mathematical formalism for emergence

As described in the editorial opening the first issue, E:CO is aiming at the intersection of three gaps:

- The distance between academic theory and professional practice;
- The space between the mathematics and the metaphors of complexity thinking; and,
- The disparity between formal idealizations and actual human organizations.

Because the following paper is an elegant mathematical formalism, it may at first impression appear to depart from the above stated aims of our journal. Dr. Sulis's paper is indeed challenging due to both its mathematical and philosophical rigor as well as the innovations expressed in its novel constructs and terminology. We find in it a plethora of new terms such as ‘semantic frames’, ‘informons’, ‘tapestries’, ‘weaving’, ‘loci’, ‘nexi’, ‘struts’, ‘constructors’, ‘relators’, and ‘labels’. A danger in the use of such neologisms is the possibility of prompting a reaction similar to the one that greeted the introduction of the abstruse later metaphysical work of the eminent English mathematician Alfred North Whitehead. When Whitehead's metaphysics debuted at the University of Chicago during the 1920s, one celebrated professor exclaimed, "It is infuriating, and I must say, embarrassing as well, to read page after page of relatively familiar words without understanding a single sentence" (quoted in Meland, 1962). Yet, in spite of this initial reaction, Whitehead's later work went on to have a profound effect in prefiguring many aspects of current complexity theory across a variety of fields such as theoretical biology, the neurosciences, philosophy, and theology.

I want to reassure the readers, however, that even in spite of its new phraseology, Sulis's paper is much more accessible than Whitehead's later work since Sulis deals with philosophical and mathematical issues in a straightforward manner, offering helpful illustrations along the way. Furthermore, we have placed the actual notation in the Appendices. This leaves the body of the text available for Sulis's careful and clear explication of emergence via his novel mathematical objects, their interrelationships, and the philosophical underpinning of his formalism. The reason we are including Sulis's paper here at all is a very simple one, namely, we deem it a ground-breaking piece of work whose difficulty is outweighed by the significance of the insights and understanding it grants into emergence.

A mathematically buttressed philosophy of emergence

Sulis's formalism has managed to integrate into one, unified conceptual edifice a novel mathematical formalism along with critical issues stemming from such diverse philosophical fields as epistemology, ontology, semantics, and even the postmodern themes of context, narrative, interpretation, and multiple perspectives. The latter theme of perspectivalism is at the core of Sulis's idea of 'semantic frames' which can be considered as cognate to suggestions along similar lines offered in the papers by Mitchell (2005) and Stengers (2005) in the first volume of E:CO. Moreover, Sulis's formalism brings the notions of meaning and interpretation right into his definition of emergence by way of his constructs of semantic frames and tapestries. Through the use of these two key elements, not only does his formalism then supply a mathematical support for the often heard claim of the irreducibility of emergent phenomena, his process ontology can be said to restate the early emergentist focus on internal relations as that which constitutes the 'whatness' of an emergent, thus recapitulating the rejection of the distinction between primary and secondary quality that was offered by Whitehead under the influence of Bradley, James, and Dewey (see Goldstein, in preparation).

Sulis's formalism is a decidedly process-based approach since it serves to cover both entities and the relationships between entities as well as the processes by which entities and their relationships undergo transformation. Although the term ‘archetypal’ of ‘archetypal dynamical systems’ was partly inspired by Jung's use of the term, the reader will notice that Sulis's formalization of emergence is not restricted to Jungian or any other psychological, philosophical, or scientific orientation. In fact, as far as the author of this introduction is aware, Sulis's 'archetypal dynamical systems' is the first truly novel mathematical formalism...
Emergence has opened up by contemporary research into complex systems. The physicist John Cramer (1997) has ably described this suggested that a well thought out formalism "lends us wings and armor" in order to "penetrate where intuition falters" (quoted in 1999). Along the same lines, the mathematical logician John Myhill, also under the sway of Gödel's great limitative theorems, of the formal and the intuitive" by which Gödel's protegé Hao Wang described his mentor's remarkable theorems (Yourgrau, 1996). In this regard, for example, Sulis introduces an intriguing and useful distinction between vertical and horizontal emergence. While vertical emergence refers to the typical scenario whereby there is an emergence of new order at a 'higher' temporal/spatial scale than the 'lower' temporal/spatial scale out of which this new order emerges, horizontal emergence involves the same temporal/spatial on the part of the emergent and that from which it emerges. An example of the former might be emergent phenomena even the kind of the thing that can be formalized at all? A negative answer to this question was indeed one of the hallmarks of the very rich and influential work of the complexity oriented theoretical biologist Robert Rosen (1996; cf. also de Lorenzana, 1993; as well as my critique of Rosen's position in Goldstein, in preparation)[2]. Sulis's formalism though suggests that the formalism was put forward without any means for empirically validating their proposals. Sulis's formalism however is not subject to the same criticism for it is not being put forward as a mathematical formalism of nature but rather as a formalism focusing on how we epistemically provide meaning and interpretation in identifying emergent phenomena. That is, Sulis is not claiming nature works precisely according to his formalism but rather how emergence is intimately involved with how we construe emergent phenomena. In this context, he offers his own computational simulations, TiGoRS (Transient Induced Global Response Stabilization) which are non-autonomous dynamical systems exhibiting a stable dynamical response to specific patterned inputs – more on this in his paper.

The challenge of a new formalism

In regard to formalization in general, emergence has, by its very nature, prompted a critically important question, namely: Is emergence even the kind of the thing that can be formalized at all? A negative answer to this question was indeed one of the hallmarks of the very rich and influential work of the complexity oriented theoretical biologist Robert Rosen (1996; cf. also de Lorenzana, 1993; as well as my critique of Rosen's position in Goldstein, in preparation)[2]. Sulis's formalism though suggests an affirmative answer to the same question. Moreover, his formalism cuts across and includes various types of emergent phenomena. In this regard, for example, Sulis introduces an intriguing and useful distinction between vertical and horizontal emergence. While vertical emergence refers to the typical scenario whereby there is an emergence of new order at a 'higher' temporal/spatial scale than the 'lower' temporal/spatial scale out of which this new order emerges, horizontal emergence involves the same temporal/spatial on the part of the emergent and that from which it emerges. An example of the former might be the emergence of an organism out of cells whereas that of the latter could be the emergence of the diversification of languages.

I have found it helpful to understand Sulis's formalism of archetypal dynamical systems as following the same sort of "dialectic of the formal and the intuitive" by which Gödel's protegé Hao Wang described his mentor's remarkable theorems (Yourgrau, 1999). Along the same lines, the mathematical logician John Myhill, also under the sway of Gödel's great limitative theorems, suggested that a well thought out formalism "lends us wings and armor" in order to "penetrate where intuition falters" (quoted in Yourgrau, 1999: 126). Indeed, I would argue that such novel formalisms for emergence as Sulis is offering not only provide conceptual advantages, they have indeed become a necessity by supplying the means for venturing into the new territories opened up by contemporary research into complex systems. The physicist John Cramer (1997) has ably described this...
advantage of a cogent formalism: “The right underlying mathematical structure enhances and enriches the physical theory that uses it... If the wrong mathematical structure is used the physical theory does not fit. The formalism must be bent out of shape to conform to it, leading to obscurity, paradoxical implications, and other problems” (p. 236). A formalism like that offered by Sulis can faithfully represent the essential features, relationships, and processes at play in emergent phenomena while at the same time doing this in a simpler way than merely observing them ostensibly.

Of course, getting conceptually lost is an unavoidable risk when it comes to entering new conceptual territory. Formalisms like Sulis’s, though, can provide landmarks amidst the complexity of complex systems that help us better navigate through them although at first impression these new landmarks themselves may be hard to recognize precisely because of their novelty. We need to become accustomed to the new constructs just as we need to gradually learn the general topography of streets in a new city in order to eventually drive around it with greater alacrity and confidence.

A formalism by itself, of course, is not to be taken as a final answer for it is more like the scaffolding for a building than the actual building itself. This corresponds to what Gödel once wrote about our intuition about space, “a point is not part of the continuum but a limit between two parts... According to this concept, all the points do not add up to the line but only make up a scaffold (Gerüst) or a collection of points of view” (quoted in Yourgrau, 1999: 213). Gödel’s remark, in fact, fits rather nicely with Sulis’s perspectivalist explanation of emergence as a collection of various non-isomorphic semantic frames or tapestries. A helpful formalism is one in which there is an active feedback between its abstract conceptual edifice and the scientific formulations arising out of it. This feedback allows one to escape that cul de sac of conceptual insularity that has arisen in certain so-called think tanks of complexity theory, which can be said to be living within a kind of computational hermetic circle. Of course, a building is neither identical to its blueprint nor the scaffolding used in building it, yet the blueprint and the scaffolding provide otherwise indispensable access to the structure of the building just as the building fleshes out the blueprint and the scaffolding.

Finally, I suggest that one way to approach the challenge of Sulis’s paper is to see it as an example of what Isabelle Stengers (2004) has pointed to as the fruitful friction between traditional abstractions and novel speculations offered in response to those traditional constructs. Here she was alluding to the conceptual friction generated by Whitehead’s immediate appeals to experience versus abstraction offered for abstraction’s sake. It is our hope that similar frictions will be prompted by grappling with Sulis’s formalism, setting off new cascades of meaningful associations. Accordingly, we sincerely hope Sulis’s pioneering paper prompts its readers to respond.

Notes

[1] Nor is Sulis’s formalism of archetypal dynamical system put forward as simply some arcane mathematical formalism recalcitrant to visualization, a concern found in contemporary physics in regard to such formalisms as string theory which has long left the earthly realm for the pure abstractions of algebraic geometry, a fact shown by how one of the chief architects of string theory, the brilliant mathematical physicist Ed Witten won the Fields Medal in mathematics in recognition of conjectures first arising in his study of string theory.

[2] Rosen explicitly defined emergence as precisely that which was not formalizable, and if something was indeed found to be formalizable then for that reason alone it couldn’t be genuinely emergent. Rosen was offering an argument based on his interpretation of Gödel’s and Turing’s famous limitative theorems in mathematical logic which is too detailed to go over here but elsewhere (Goldstein, In Preparation) I have critiqued Rosen’s claim by turning it inside out so to speak.

References


Emergence: Complexity and Organization


