Emergence: The Achilles Heel of Systems Thinking

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Abstract

This paper examines concept of 'emergence' and its underlying acceptance by system theory. Stating that a 'system' has properties greater than the sum of its parts can only be explained by system theorists as 'emergence'. Thus, the explanation of a phenomenon has been avoided by creating a 'mystery' – that of emergent properties. Whilst this might be a pragmatic avenue to make sense of the world, it evades further investigation. The use of a bottom up approach exposes the negative side of the concept of emergence in real world problem solving, and also the acceptance of the fatalist assumption of 'that is the way things are.' In a sense, it is both a reductionist's argument against lack of rigour and vague notions of system theory, and also an indicator that perhaps systems' theorists can only justify their theories by a belief in something higher than the physical and observable world.

Keywords: System theory, network theory, management, bottom-up techniques.

Systems and Emergence

Richmond (1994, p. 139) states that systems thinking is *"the art and science of making reliable inferences about behaviour by developing an increasingly deep understanding of underlying structure"*. At an operational level, system thinking is both a paradigm (a vantage point and set of thinking skills) and a learning method (a process, language and technology).

Contemporary systems thinking can be said to have been initiated by Bertalanffy (1951, 1969). His work on developing a General Systems Theory (GST) began a process whereby a more holistic approach to problem solving was added to the reductionist tools of science. The cliché that says a system 'is more than the sum of its parts' brought about the idea that systems have characteristics that could not be predicted by conventional analysis. The inter-relationships and interactions between entities became just as important as their constituent parts. Some of the fundamental system concepts developed were: emergent properties, boundaries, inputs and

outputs, purpose, hierarchy, entropy, interaction and transformation (Checkland, 1992).

The levels of systems/holistic thought have been classified by Phillips (1976) into three types:

Holism 1 (organicism)
The assumptions here are:

- the analytic approach when applied to biological organisms, society, or reality as a whole, proves inadequate,
- the whole is more than the sum of its parts,
- the whole determines the nature of its parts,
- the parts cannot be understood if considered in isolation from the whole, and
- the parts are dynamically inter-related, or, independent.

These can be opposed by supporters of the analytic/mechanistic methods although several can be accepted by them. The main issue with holism 1 is the concept of **emergent properties** of systems, although here the understanding is that these properties can be eventually explained in terms of the individual characteristics of the parts. Underlying this is the Newtonian paradigm, even if there is an admission of the inadequacy of traditional analytical methods to explain system behaviours.

Holism 2
This states that the whole, even after it is studied, has emergent properties that cannot be explained in terms of its parts. This is more contentious, and is opposed by reductionists. It implies that systems can have a **vital force**, much as a living human body can be perceived to be more than a combination of heart, lungs, brain, and so on. Holism implies that scientific investigation is inadequate to explain the behaviour of complex systems.

Holism 3
This states that it is necessary to have terms of reference to the whole and its properties. This is acceptable to supporters of reductionism, and merely emphasises that systems can have properties as can their parts. It is therefore valid to study systems independently from studying their parts.

Espejo (1994, p. 202) sees a system as:

> *"...first of all a way of looking at the world. It is a mental construct of a whole, for which it is possible to establish a set of inter-related parts that make up the perceived whole...The system - its identity, parts, and relationships - cannot be anything else but a construct or distinction by an observer; and different observers in different contexts and with different purposes may make different distinctions. In this sense, defining a system is viewpoint-dependent. "*

This approach posits the concept of the 'system' being solely a mental construct which underlies much of soft systems thinking. The boundary of the system is therefore an arbitrary mental construct. This means that system definitions will vary from person to person. Whatever the definition of a system, the concepts of **emergence** and emergent properties are prevalent.

The Problem with Emergence

Is 'emergence' just a term used for phenomena that we cannot explain or predict? An anonymous (2001) writer posits that emergence might mean that we cannot predict the properties. However, the argument goes further. Does this denote that we cannot **foresee** or **prognosticate** the properties or does it mean we cannot **deduce** or **explain** them? For instance, the combination of hydrogen and oxygen into water might not have been an obvious emergent property in the 13th century. However, does this make the properties of water an emergent property except in a trivial sense? In the contemporary world, it is an observable fact. So are the other emergent properties just our way of coping with a lack of understanding? A way of making complex and problematic problems become acceptable to our vain intellects: if we cannot understand it then it is an emergent property. Even Markic (2003) who attempts to make a distinction between traditional and connectionist model of emergence is only really distinguishing between conventional cause and effect and less predictable and problematic causal relationships. It is just a case of distinguishing between simple and complex problems as defined by Flood and Jackson (1991). Their model says that a system is judged simple or complex by determining the following:

- the number of elements,
- the number of interactions between the elements,
- whether the attributes of the elements are predetermined or not,
- whether interactions between elements are highly organised or not,
- whether well defined laws govern behaviour in the system,
- whether the system evolves over time,
- whether subsystems pursue their own goals,
- whether the system is unaffected by behavioural influences,
- whether the system is largely 'closed' or 'open' to the environment.

If a different perspective is taken on phenomena, the shallowness of the 'emergencists' using the human body as an example can be illustrated.

The body: a bottom-up approach

If the human body is examined form a viewpoint of its components, a different viewpoint can be achieved. Normally, the body is regarded as a whole and its constituent parts broken down into organs, cells and so on. The marvels if its functions are explain in holistic terms and, as such, the cells which make it up seem to take on a different dimension. However if the cell is viewed as the starting point, a different point of view is obtained. The two gametes (sperm cell and ovum) that produce a fertilised egg start a process of asexual cell division that eventuates in a complete body. The cells divide and differentiate according to two major constraints: their genetic makeup and the ambient environment. In the mature body, its constituent parts (that is, cells) do exactly the same. From this perspective, a white blood cell is not an entity that has a function (for example, to consume foreign bacteria) but a cell that **behaves** in a specific and statistically predictable way. Some would believe that the while corpuscle has a *raison d'être* – a mystical purpose within the body's whole. Another viewpoint is that, over the eons, cell colonies (such as the body) have genetically evolved so that their behaviour in the colony has allowed the colony with cells of this genotype tend to survive. The white cell does not have any other purpose

than of survival; it just happens that the combination of cells in this genetically identical colony behave in a way conducive to survival in that particular environment. The combination of differentiated cells to produce the body is certainly a complex colony. How each cell behaves is problematic but still statistically predictable in a given environment. As the colony of cells called the 'body' contains millions of cells the combination of behaviours becomes much more problematic to predict. Nevertheless, each cell has a limited number of behaviours and a limited environmental tolerance. The 'body' in this sense and its 'emergent' properties are no more than the sum of its cells' behaviours. Its behaviour might be difficult to predict because the combinations of cell behaviours in a certain situation and at a certain time are problematic. This is caused by the cells having different behaviours to certain stimuli. Therefore, predicting the possible combinations of behaviours is very difficult, if not impossible. It is much more difficult than predicting the outcome of an oxygen and hydrogen combination. Nonetheless, the same principle theoretically applies. Thinking any other way implies that the body has a 'vital force' beyond that of its cells.

At a more practical and pragmatic level, real world problems are solved by a combination of top-down (systemic) and bottom up thinking. These two approaches roughly map onto the inferential processes deduction and induction/abduction. Waltz (2003) describes the production of models as a cyclical process of analysis and synthesis, where analysis breaks evidence into parts and identifies relationships (a top down approach) whilst synthesis assemble parts into larger constructs (a bottom up process)

The 'Emergence' Mindset and Problems of Management

Just like the body**,** government and commercial organisations can be viewed as a conceptual whole, or as a set of semi-autonomous objects (Tsoukas, 1993). Again, from the holistic perspective, the organisation is assumed to have an overt, stated purpose. Another view sees the organisation as consisting of elements (usually individuals or groups) which are all carrying out their own activities. If the purposes of these elements are beneficial to the overall purpose of the whole system, the organisation will remain healthy (in its own terms). Within the system, elements have different purposes, which may contradict the main system purpose. Thus, the organisation can have a myriad of 'purposes'. If these sub-purposes do not dominate, the organisation will still carry out its main purpose. However, a situation could occur where the sub-purposes can dominate. Hence, the actions of the system elements will not serve the overt system purpose. The priorities of system purposes will change in fact, if not officially. The recent break up of the corporate giant, Enron, is a good example of the elements within the system behaving as semi-autonomous units at complete opposition to the official stated purposes of the organisation (for an example of the many articles on this event see BBC, 2003). This behaviour resulted in the collapse on the 'system' as the components (or at least those with power) had totally different objectives those of 'artificial' and abstract corporate body.

This model illustrates the real world, chaotic character of organisations. Just like the white blood corpuscles above, individuals do not have a specific purpose as espoused by the official view of the organisation. Rather, the individual has its own purpose – it is a semi-autonomous agent reacting to its environment in limited ways. The organisation is the sum total of these interactions. Management thinking often assumes all the system elements are all working toward the main, overtly stated purpose of the organisation. People and groups of people have different agendas and motivations; assuming they correlate with the official organisational objectives is extremely naive. As Tsoukas (1993, p.514) says, "While social organisations are inevitably human artefacts, they are not necessarily the product of human design".

When an organisation is viewed in bottom up mode, each component has a set of attributes and potential. How each element behaves will be determined by that element's internal state and the behaviour of other elements affecting it. Hence, people, groups, technology, and other resources determine a system's behaviour. It is these elements, and how they interact that will determine how the system works. Therefore, examining these will give a realistic image of what is **really** happening, and any achievable potential in the system. A criticism of managers using top down styles is that, because they view everything through an organisational lens, they do not know what 'really goes on'. Managers view staff behaviour with some preconceived notion of what **should** be happening. This can cause a discrepancy between ideas and practice. It might be valid to view management problems this way to get things achieved but can cause problems if the ideal and practice are very divergent.

One major drawback of drawing a boundary around a 'concept' is that people believe it to be true, and then try to fit other people's behaviour into the context of their viewpoint. These concepts then allow managers, politicians, and us to blame some abstraction (the 'system') rather than actions they might have made taken themselves. If things go wrong, or they wish to do something which is ethically unjustified, they can claim to be victims of trends, or of 'normal' business practice. In fact, anything that will prove that people are powerless and victims of the context will be used as an explanation. However, it is the abstraction of the 'system' that is really to blame. Of course, who creates these abstractions is a mystery.

Differences in the views of those who consciously believe in emergent properties and those that do not can manifest themselves in conflicts between upper management and operational staff. For instance, in a police service, the realities of the upper ranks that have to report to political masters and the media can be in stark contrast to the realities of the street, where the consequences of individual behaviours have to be handled. It is only by realising that the whole **is** the sum of its parts that managers can appreciate the contribution of each part. Lack of concentration on components of an organisation can develop into a fatalistic 'that is the ways things are/work' attitude.

Also, a belief in emergence can develop into the perception that the organisation is greater than its people and infrastructure (physical assets). Whilst this is an accepted

paradigm, its lack of realism can result in management becoming divorced from the actuality of its operation and the neglect of environmental signals. A practice of making decisions for the benefit of an abstract (the 'company', the 'system', the 'law', 'quality', etc) becomes the norm. It is often instructive to ask oneself: "who or what is the company I am working for?" Is there a satisfactory answer to that question except that it is the sum of its component parts?

Conclusion

System thinking has relied heavily on the concept of emergence to prop up its concept of 'Wholes' or 'Holons'. Whilst this has been a useful exercise in creating social and organisational solutions, it is not without its problems. In an intellectual sense, the concept of emergent properties is on very shaky ground. It can be accepted that when two entities are put together they exhibit different properties; so in this sense they do have emergent properties. However, in the mystical sense that some system thinkers use the phrase, there is danger that credibility will be lost unless one accepts some spiritual dimension to the argument. This removes it from natural laws and the 'scientific' realm.

Humans need to form artificial mental constructs to make sense of the morass of data in their environment. A system with its boundary is such a construct. The creation of this construct inevitably leads to 'emergence' as an equally artificial concept that helps explain the conventionally, inexplicable behaviour of the experienced world.

References

Anon (2001) *Emergent properties.* URL: http://www.cscs.umich.edu/~crshalizi/notebooks/emergent-properties.html [Accessed 20 July, 2003]

BBC (2003) Third Enron Executive Arrested, URL: http://news.bbc.co.uk/2/hi/business/2961072.stm, 3rd June, 2003. [Accessed 25th October, 2003]

Bertalanffy L von (1969) General Systems Theory - critical review, *General Systems*, **IV**, 1-20

Bertalanffy L von (1951) An outline of General Systems Theory, *British Journal for the Philosophy of Science*, **1**

Checkland P (1992) Systems and Scholarship: The need to do better, *Journal of the Operational Research Society*, **43**, 11

Espejo R (1994) What is Systemic Thinking, *Systems Dynamics Review*, **10**, 2-3.

Flood R L, Jackson M C, (1991) *Creative Problem Solving: Total Systems Intervention*, Wiley, Chichester.

Markic, O (2003) *Emergent Properties*, URL:

http://ciiiweb.ijs.si/dialogues/r-markic.htm [Accessed: 4th August, 2003]

Phillips D C (1976) *Holistic Thought in Social Science*, Stanford University Press, California.

Richmond B (1994) Systems Thinking / Systems Dynamics: let's just get on with it, *Systems Dynamics Review*, **10**, 2-3

Tsoukas, H. (1993) Organizations as Soap Bubbles: An Evolutionary Perspective on Organization Design. *Sys. Pract.*, **6,** 5: 501-515.

Waltz, E. (2003) Knowledge Management in the Intelligence Enterprise, Artech House, Boston.