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On a Morphology of Theories of Emergence

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Abstract: "Emergence" – the notion of novel, unpredictable and irreducible properties developing out of complex organisational entities – is itself a complex, multi-dimensional concept. To date there is no single, generally agreed upon "theory of emergence", but instead a number of different approaches and perspectives. Neither is there a common conceptual or meta-theoretical framework by which to systematically identify, exemplify and compare different "theories". Building upon earlier work done by sociologist Kenneth Bailey, this article presents a method for creating such a framework, and outlines the conditions for a collaborative effort in order to carry out such a task. A brief historical and theoretical background is given both to the concept of "emergence" and to the non-quantified modelling method General Morphological Analysis (GMA).

Keywords: Emergence, general morphological analysis; theories of emergence, typology of emergence, modelling theory.

> *"...a perpetual and unrestricted progress of the universe as a whole must be recognized, such that it continually advances to a higher state of being."*
> G. W. Leibniz, *De rerum originatione radicali*, 1697

> *"...the universe is a process for breeding novel phenomena and states of organization, which will forever renew itself as it evolves to states of ever higher complexity and organization."* Lee Smolin, *Time Reborn*, 2013.

1. Introduction

The doctrine of *emergence* states that new properties, in the form of new types of behaviour, new entities and even new forms of lawfulness, can "emerge" out of complex organisational systems; and that these properties cannot be predicted from, nor reduced to, the properties of the components making up the system. This is expressed in the well-known (and well-worn) aphorism: "The whole is more than the sum of its parts".

The general idea of emergence is as old as rational science itself. Its basic concept was acknowledged by both Plato and Aristotle, and it was one of the principles of neo-Platonism, both in its earlier versions (e.g. Plotinus) and its later Renaissance versions. It lay at the foundations of the German ("Eastern") Enlightenment and was "naturalised" by the British in the 1920's.

The latest round of scientific and philosophical discussions concerning emergence came to life (or *re-emerged*, as many enjoy putting it) in the 1980's with developments in the areas of complex adaptive systems, computational modelling, theoretical biology (anticipatory systems), sociocybernetics and theories of mind and consciousness. Along with this came a new interest in the philosophical (and ontological) issues involved.

The current literature on *emergence theory* is extensive and there is no need here to present more than a short summary explanation of the concept itself. Except for the deplorable state of Anglo-centric *histories of the development of the concept of emergence*[*], interested readers can find excellent presentations in two anthologies: Clayton & Davies (2006) is a set of 14 articles written by contemporary researchers; and Bedau & Humphreys (2008) is a sourcebook of some 25 "historical" articles written between 1970 and early 2000. Besides covering the central scientific and philosophical issues involved, these articles give a good picture of the diverse views concerning what the notion of emergence actually represents: from nothing more than a "new animist fantasy" to being a central issue for the next scientific revolution.

Of course, the cliché "the whole is more than the sum of its parts" will not do; it tells us nothing about what is actually going on. A more in-depth definition of emergence is required. Several have been proposed. Generally, three interconnected issues have been identified (see e.g. Kim, 1999; El-Hani & Pihlström, 2002):

1. *Property emergence*: When systems of objects attain an appropriate level of organizational complexity, genuinely novel (unpredictable) properties can appear at the level of the system *as a whole*.

2. *Irreducibility*: Emergent properties are not only unpredictable from, but *irreducible to*, the lower-level constituents from which they emerge

3. *Downward causation*: Emergent properties, as higher-level entities, manifest genuinely novel causal powers which affect their lower-level constituents in ways that could not be actualised at the level of the interaction of the constituents themselves. This is also referred to as *higher-level* or *global supervenience* (see Paull & Sider, 1992 for a detailed discussion).

But this "definition" is just a starter. First of all, there are two general approaches to studying emergent phenomena: the *synchronic* and the *diachronic*.

The *synchronic* approach studies the emergent properties of a given system *here and now*. It does not concern itself with how these properties, or the system that embodies them, *came into existence* or *evolved over time*. For instance, the study of the already existent phenomenon of *mind* as an emergent property of the *brain* represents a synchronic approach. This was put forward, for example, by Sperry (1983).

The *diachronic* approach studies the *development* of emergent properties *over time*, i.e. as an evolutionary process (and thus is called evolutionary emergence). For instance, how human (self-reflexive) consciousness emerged in the development of *homo sapiens* over the past million is an example of the diachronic approach. At this point in time, these two approaches are not (conceptually) integrated.

Another issue is the question of just how much emergence is actually going on. For instance, Morowitz (2004) – in his aptly titled book *The emergence of everything* – sees it literally everywhere, from the large scale structure of the universe, to language and the concept of God. At the other end of the spectrum is the Australian philosopher and *consciousness scientist* David Chalmers (2006), who only recognizes one "real" or genuine case: the emergence of reflexive self-consciousness from the human brain. Similarly, Vladimir Vernadsky (1986, 2007), the Ukrainian geo-biochemist working in the 1920's and 30's, concentrated on the "two great emergent events": the emergence of the *biosphere* from the *geosphere*, and the emergence of the *noösphere* from the *biosphere*.

[*] This deserves an article in itself. While Anglo-Saxon histories make it clear that there is no room for emergence in the mechanical, clock-work world of the British Enlightenment (essentially based on the Locke-Newton program), these histories are written as though G.W. Leibniz never existed, and as though the German Aufklärung (the "Eastern Enlightenment") never took place. Not only did the German version of the Enlightenment *accommodate* emergence; it was essentially *based* upon the idea. Furthermore, there is seldom any mention of the fact that the purported British "founders" of emergence – J.S. Mills and G.H. Lewes – freely admit that they were directly influenced by the writings of the German emergentists Herder and Goethe. Indeed, what Anglo-Saxon science did with these classical German scholars fully justifies Janik & Toulmin's (1996) statement: "… one of the gravest misfortunes that can affect a writer of great intellectual seriousness and strong ethical passions is to have his ideas 'naturalized' by the English" (p.19).

These different attitudes to what is, and what is not, to be considered real or genuine emergence brings us to perhaps the fundamental issue – the great divide – in modern emergence theory, i.e. the *ontological status* of emergence.

The *great divide* is between what has come to be called "strong" vs. "weak" theories. Strong theories of emergence (a.k.a. *ontological emergence*) regard emergent properties and "downward causality" (higher-level supervenience) as *ontologically real,* representing genuinely new causal agents and processes. Sperry's (1983) concept of consciousness as a non-reducible property and a causal agent having downward influence over cerebral function is an example of strong emergence.

Weak emergence (a.k.a. *epistemological emergence*) regards emergence as a *methodological* issue only, i.e. that all causality "really" only comes from below, i.e. from the physical substrate. Certain higher-level phenomena may be unexpected, but that is because we lack the requisite knowledge and scientific methods to rigorously account for these emergent phenomena. In principle, however, they are completely deducible from laws concerning the lower-level (material) domain from which they have emerged.

One may ask if there is any practical issue involved in this theoretical divide: if both sides of the argument are willing to accept the *phenomena* of emergence, what does it matter?

It matters immensely. Although there are certainly different shades of weak emergence, in both the early (1920's) British Emergentists (see e.g. Alexander, 1920; Morgan, 1923; Board, 1925; White-head, 1929) and contemporary texts (especially from the natural sciences), the essentials are clear: to the extent that such weak theories see emergence simply as a sign of our (i.e. science's) *ignorance* concerning how to correctly apply reductionist methods to higher levels of organisation, then it is but an updated version of the traditional empiricist-reductionist program: you accept the *phenomenon* of emergence, but essentially deny its "reality". As Herbert Simon (1996, p.171) points out, "... this weak form of emergence poses no problems for even the most ardent reductionist."

Strong emergence, on the other hand, has profound consequences for science and the understanding of nature:

> "Strong emergence has much more radical consequences than weak emergence. If there are phenomena that are strongly emergent with respect to the domain of physics, then our conception of nature needs to be expanded to accommodate them. That is, if there are phenomena whose existence is not deducible from the facts about the exact distribution of particles and fields throughout space and time (along with the laws of physics), then this suggests that new fundamental laws of nature are needed to explain these phenomena. (Chalmers, 2006, p 245.)
>
> "…if we are correct about macro-determination or 'emergent determination' … [then] the result is a vastly transformed scientific view of human and non-human nature."
> (Sperry, 1986, p 269, cited in McLaughlin, 2008.)

Despite this basic dichotomy, the one thing that most would agree upon is that the notion of emer-gence itself is a complex, multi-dimensional concept; and that, to date, there is no single, generally agreed upon *theory of emergence*. Instead there are many variations of such theories. In addition, there seems to be no common meta-theoretical framework by which to systematically identify, exemplify and compare such different theories.

This article proposes a method for initiating the development of such a meta-theoretical framework. It is built upon earlier work done by Kenneth Bailey, Professor of Sociology (retired) at the Univer-sity of California at Los Angeles (U.C.L.A.). Bailey's work on the classification of theories of emer-gence was done in the area of social systems and sociocybernetic theory. However, we feel that the concepts he treated in this area are expressed at a level of abstraction that make them relevant, as least as a starting point, to theories of emergence *generally*.

This article is divided up into the following sections:

Section 2 presents Bailey's earlier typological analysis of emergence as concerns social systems.

Section 3 gives a short background to General Morphological Analysis (GMA), *for those readers who are new to this area.*

Section 4 presents an outline for the development of a meta-theoretical framework for theories of emergence, in the form of a morphological inference model.

2. A Typology of Theories of Emergence

In 2006, Kenneth Bailey, Professor of Sociology (now retired) at U.C.L.A. presented a paper at the International Sociological Association XVI World Congress in Durban titled: "A Typology of Emergence in Social Systems and Sociocybernetic Theory" (Bailey, 2006). There he pointed out that although there is a general consensus within social systems theory that *emergence* is an important concept, there is a wide variety of descriptions of this concept in the literature. These different descriptions (or perspectives) derive from the fact that *emergence* is a multidimensional concept, and that researchers differ in their approach to this concept in two ways: 1) what *types of dimensions* they use in order to define the *problem space* of the concept, and 2) how they *position themselves* with respect to the issues implicit in those dimensions.

Ken Bailey has been a leading figure in modern typology theory, in a direct line from Lazarfeld (1937, 1951) and McKinney (1969). Thus it was natural for him to approach this problem from the standpoint of typology analysis:

> "Perhaps the best way to adequately present and analyze all of the dimensions of emergence is through a typology. The purpose of this paper is to construct this typology. The typology will subsequently be used as a mechanism for recognizing and analyzing the various types of emergence that exist in contemporary social systems theory and socio-cybernetics, with the aim of ultimately eliminating much of the confusion that now surrounds the concept of emergence." (Bailey, 2006. p. 2)

A typology (the Greek word *typos* originally meant a hollow mould or matrix) is a very simple (usually non-quantified) model based on the possible combinations obtained between a few (often two) variables, each containing a range of discrete values or states. A typology inter-relates a number of "simple" (one dimensional) concepts in order to create and explore the more complex (multi-dimensional) concepts which are *compounded* out of these simple concepts.

In order to produce a typology of emergence, Bailey *substructed* a number of already existing theoretical frameworks for the notion of emergence. *Substruction* – advanced by Lazarfeld (1937) – is the process of examining the *attributes* of an existing (multidimensional) concept in order to identify and specify its underlying (conceptual) *dimensions*, which can then be juxtaposed in a typological field in order to find *all of the other possible combinations of attributes.*

Bailey carried out substructions on works by Buckley (1998), Luhmann (1995), Miller (1978) and Mihata (1997), as well as his own work on emergence. Out of these substructions, twelve (binary) factors or *parameters* were identified for the determination of different conceptions of emergence. (Note: I am using the term *parameter* here not in its formal mathematical sense, but in its more general, systems science meaning: i.e. one of a number of factors that define a system and determine its behaviour, and which can be varied in an experiment, including a *Gedankenexperiment.*)

The 12 parameters are:

1. Linear vs. nonlinear
2. Static vs. dynamic
3. Evolutionary vs. Non-evolutionary
4. Ordered vs. Non-ordered
5. Simple vs. Complex
6. Non-hierarchal (two-levels) vs. Hierarchical (>2 levels)
7. Transformational vs. New variable emergence
8. Small vs. Large
9. Old (variable transformation) vs. New (variables emergence)
10. Bottom-up vs. Top-down
11. Aggregative vs. Divisive
12. Non-nested (autonomous) vs. nested (non-autonomous)

Twelve binary parameters produce 2^{12} = 4096 combinations of attributes which represent possible (*formal*) frameworks for a theory of emergence. (This does not mean that all of these *formal* frameworks are logically or epistemologically possible.)

However, twelve variables (even if they are only binaries) are too much to treat in a normal (paper-based) *typology*.

> "The usual procedure would be to form the 12-dimensional typology through substruction, then to use various forms of reduction to reduce the number of types below 4096. However, given the large number of cells in the full typology, and the fact that the full 12-dimensional typology cannot be presented on a two-dimensional sheet of paper, it behooves us to reduce the number of dimensions before proceeding to the reduction of types". (Bailey, 2006, p. 19.)

Bailey proceeds to reduce the number of parameters by searching for *collinearity*. Simply put, if two parameters, taken from two different research approaches, essentially express the same concept, then they can be fused into a single parameter. Thus by a process of merging similar concepts, Bailey reduces the number of dimensions to *four* (which is pretty much the comfort-limit for typology construction "on paper").

1. Non-hierarchal (2-level) vs. Hierarchical (>2 levels)
2. Non-nested (autonomous) vs. Nested (non-autonomous)
3. New variable emergence vs. Old variable transformation
4. Bottom-up emergence vs. Top-down emergence

These four binary parameters create 2^4 (=16) *type-cells* in the typological field (Figure 1). Since the parameters defining this field were substructed from specific concepts of emergence already expressed by different researchers, it is a straight-forward process to plug them back in to their appropriate positions along the four dimensions.

Here we see that Bailey has identified seven *actual* (i.e. currently employed) versions of emergence and hypothesised two (possible) new versions. In addition, there are seven "Not Yet Identified" (NYI) versions. (What is not made explicit here is the question of whether all of these NYIs are, in fact, *possible*, or, if not, which are logically or epistemologically *impossible*.)

		Not Nested		Nested	
		Bottom-up	**Top-down**	**Bottom-up**	**Top-down**
Non-hierarchical	**NEW**	NYI	Luhmann	Bottom-up, new variable emergence (NEW)	NYI
	OLD	NYI	Luhmann	(Buckley, Mihata, Luhmann) BML "Pattern emergence"	NYI
Hierarchical	**NEW**	NYI	Luhmann	New Variable (Miller) Evolutionary emergence (Mihata)	NYI
	OLD	NYI	Luhmann	Transformational emergence (Miller) Mergers & Acquisitions	Divisive Nested Emergence "Spin-Off" (NEW)

Figure 1. Bailey's four dimensional typology of emergence reduced from 12 binary parameters (adapted from Bailey, 2006, p.27.)

Bailey was compelled to reduce the number of dimensions *first*, instead of utilising all of the 12 identified (substructed) dimensions and *then* reducing the number of types through the systematic comparison and evaluation of their attributes. In this case, the *pre-reduction* was justified, but has a price-tag: unless you are absolutely certain that you have only removed (or merged) dimensions that are essentially *identical*, then you may have discarded possible versions of theories of emergence, which might have implications for the whole notion of the concept. (I interpret Bailey's text such, that he would have preferred to type the whole 12 dimensional complex, had he had the practical methodological tools to do so.)

Computer-aided morphological analysis allows us to comfortably work with 12 binaries. It also has some additional benefits. First of all, it will allow us to (explicitly) make the distinction between 1) identified *actual* (i.e. currently employed) *theories* of emergence; 2) "Not Yet Indentified" *possible theories* of emergence; and, 3) (logically or epistemologically) *impossible theories* of emergence.

Secondly, GMA's Cross-Consistency Assessment (CCA) systematically identifies duplicate and even partially overlapping (non-orthogonal) parameters, thereby allowing for the reduction of dimensions in a methodical and transparent manner, *after such parameters have been given their chance*, so to speak. Also, with computer support it is possible to delete, merge or add new parameters at any time, without having to back-track and re-evaluate internal consistency.

Finally, by identifying all possible (internally) consistent conditions for all possible theories of emergence (at least as these are defined among the attributes of the dimensions employed), the morphological field can be treated as a ("what-if") inference model. This will allow us to posit questions (initial inputs) and obtain answers (outputs) from the model. For instance: given a theory of emergence that is *nested* and *top-down*, what are the possible variations of this theory along the other dimensions, and which of these (if any) are logically or epistemologically impossible?

In Section 4, we will put forward a method for accomplishing this task in more detail. First, a short background to General Morphological Analysis (GMA) is presented – *for those who are not previously acquainted with this method*.

3. Background to General Morphology*

The term *morphology* derives from ancient Greek (*morphê*) which means *shape* or *form*. Morphology is "the study of form or pattern", i.e. the arrangement and connectivity of parts of an object, and how these conform to represent a whole or Gestalt. The "objects" in question can be physical (e.g. an organism or an ecology), social/organizational (e.g. an institution or company), or mental (e.g. linguistic forms or any system of ideas).

In Europe, morphological methods were used as early as 1290s by the theologian-logician Ramon Llull (1232-1315) in his *Ars magna* ("The Ultimate General Art"). Gottfried Leibniz (1646-1715) later developed it into a modern, grounded method in his *Ars combinatoria*. However, the first to use the term "morphology" as an *explicitly defined scientific method* would seem to be J.W. von Goethe (1749-1832), especially in his "comparative morphology" in botany. Today, morphology is associated with a number of scientific disciplines where *formal structure* is a central issue, for instance, in anatomy, linguistics, geology and zoology.

In the late 1940's, Fritz Zwicky, professor of astrophysics at the California Institute of Technology (Caltech) proposed a *generalized form of morphology*, which today goes under the name of General Morphological Analysis (GMA)

> "Attention has been called to the fact that the term *morphology* has long been used in many fields of science to designate research on structural interrelations – for instance in anatomy, geology, botany and biology. ... I have proposed to generalize and systematize the concept of morphological research and include not only the study of the shapes of geometrical, geological, biological, and generally material structures, but also to study the more abstract structural interrelations among phenomena, concepts, and ideas, whatever their character might be." (Zwicky, 1969, p. 34)

Zwicky developed GMA as a method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable, problem complexes. He applied the method to such diverse fields as the classification of astrophysical objects, the development of jet and rocket propulsion systems, and the legal aspects of space travel and colonization. He founded the Society for Morphological Research and championed the "morphological approach" from the 1940's until his death in 1974.

Morphological analysis was subsequently applied by a number of researchers in the USA and Europe in the fields of policy analysis and futures studies. In1995, advanced computer support for GMA was developed at the Swedish Defence Research Agency (FOI) in Stockholm. This has made it possible to create non-quantified inference models, which significantly extends GMA's functionality and areas of application. Since then, some 100 projects have been carried out using GMA, for structuring complex policy and planning issues, developing scenario and strategy laboratories, and analyzing organizational and stakeholder structures†.

Essentially, GMA is a method for identifying and investigating the total set of possible relationships contained in a given problem complex. This is accomplished by going through a number of iterative phases which represent cycles of analysis and synthesis – the basic method for developing (scientific) models (Ritchey, 1991).

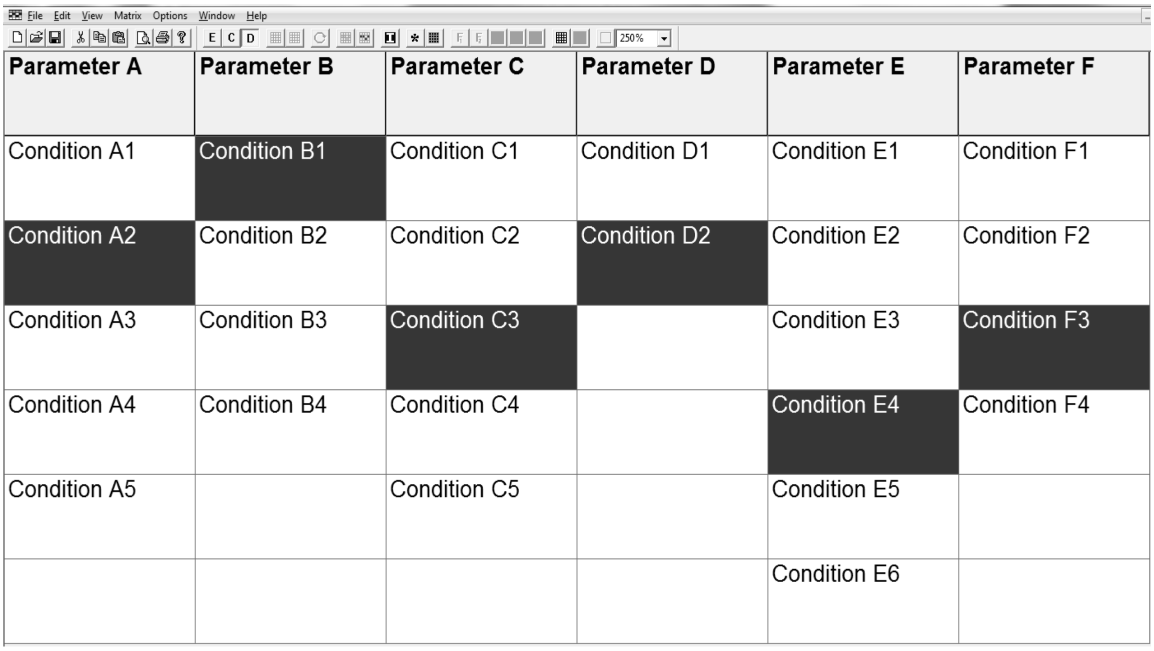
* For a more detailed presentation, see the JORS article:" Problem Structuring with Computer-Aided Morphological Analysis" at: http://www.swemorph.com/pdf/psm-gma.pdf.

† For a list of projects see: http://www.swemorph.com/projects.html

The method begins by identifying and defining the most important *parameters* of the problem complex to be investigated, and assigning each parameter a range of relevant *values* or *conditions*. This is done mainly in natural language, although abstract labels and scales can be utilized to specify the set of elements defining the discrete *value range* of a parameter.

A morphological field is constructed by setting the parameters against each other in order to create an n-dimensional configuration space (Figure 2). A particular *configuration* (the black cells in the matrix) within this space contains one ”value” from *each* of the parameters, and thus marks out a particular state of, or possible formal solution to, the problem complex.

The point is, to examine all of the configurations in the field, in order to establish which of them are possible, viable, practical, interesting, etc., and which are not. In doing this, we mark out in the field a relevant *solution space*. The solution space of a Zwickian morphological field consists of the subset of all the possible configurations which satisfy some criteria. The primary criterion is that of *internal consistency*.



Parameter A	Parameter B	Parameter C	Parameter D	Parameter E	Parameter F
Condition A1	Condition B1	Condition C1	Condition D1	Condition E1	Condition F1
Condition A2	Condition B2	Condition C2	Condition D2	Condition E2	Condition F2
Condition A3	Condition B3	Condition C3		Condition E3	Condition F3
Condition A4	Condition B4	Condition C4		Condition E4	Condition F4
Condition A5		Condition C5		Condition E5	
				Condition E6	

Figure 2: A 6-parameter morphological field. The darkened cells define one of 4,800 possible (formal) configurations.

Obviously, in fields containing more than a handful of variables, it would be time-consuming – if not practically impossible – to examine all of the configurations involved. For instance, a 7-parameter field with 6 conditions under each parameter contains almost 280,000 possible configurations.

Thus the next step in the analysis-synthesis process is to examine the *internal relationships* between the field parameters and reduce the field by weeding out configurations which contain mutually contradictory conditions. In this way, we create a preliminary outcome or solution space within the morphological field without having first to consider all of the configurations as such.

This “reduction” is achieved by a process of *cross-consistency assessment* (CCA). All of the parameter values in the morphological field are compared with one another, pair-wise, in the manner of a cross-impact matrix (Figure 3). As each pair of conditions is examined, a judgment is made as to whether – or to what extent – the pair can coexist, i.e. represent a consistent relationship. Note that there is no reference here to direction or causality, but only to mutual consistency. Using this technique, a typical morphological field can be reduced by to 90% or even 99%, depending on the problem structure.

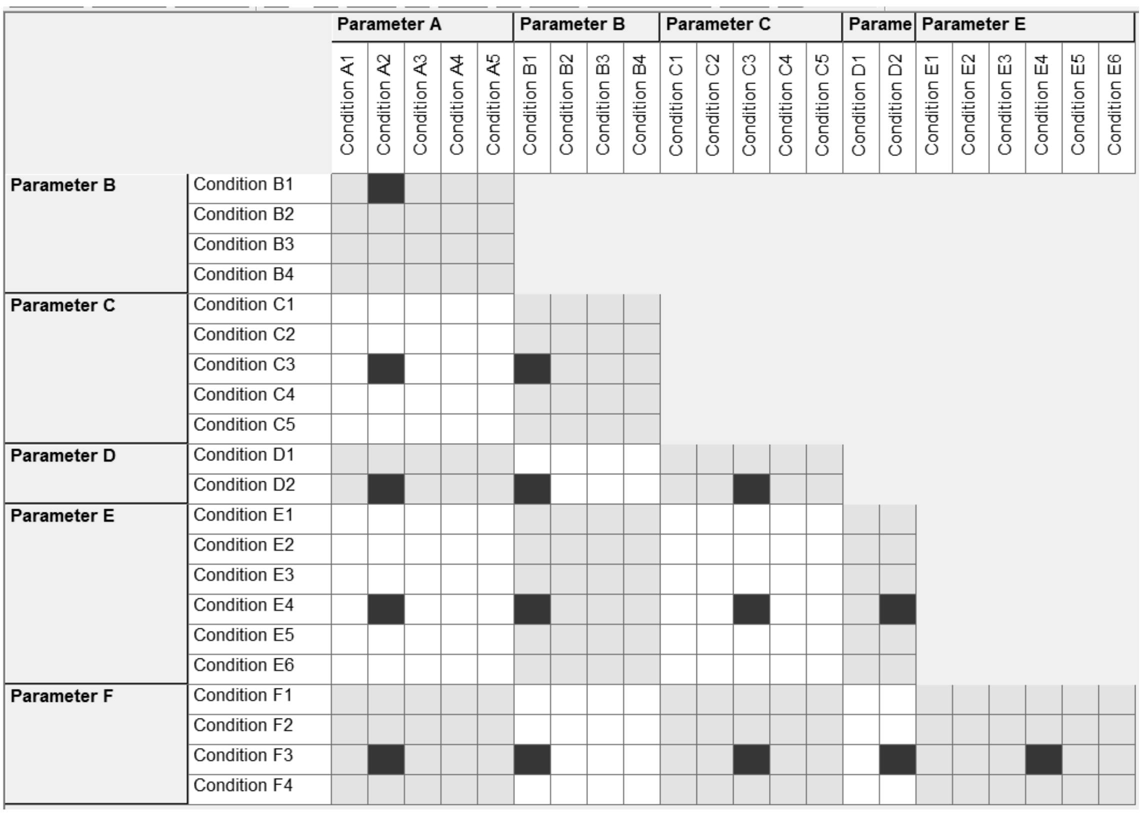


Figure 3: The Cross-Consistency matrix for the morphological field in Figure 1. The dark cells represent the 15 pair-wise relationships in the configuration given in Figure 1.

There are three principal types of inconsistencies involved in the cross-consistency assessment: purely *logical* contradictions (i.e. contradictions in terms); *empirical* constraints (i.e. relationships judged to be highly improbable or implausible on practical, empirical grounds), and *normative* constraints (although these must be used with great care, and clearly designated as such).

This technique of using pair-wise consistency assessments, in order to weed out internally inconsistent configurations, is made possible by the combinatorial relationships inherent in morphological models, or in any discrete configuration space. While the number of configurations in such a space grows factorially with each new parameter, the number of *pair-wise relationships between parameter conditions* grows only in proportion to the triangular number series – a quadratic polynomial. Naturally, there are also practical limits reached with quadratic growth. The point is, that a morphological field involving as many as 100,000 formal configurations can require no more than few hundred pair-wise assessments in order to create a solution space.

When this solution (or outcome) space is synthesized, the resultant morphological field function as an *inference model*, in which any parameter (or multiple parameters) can be selected as "input", and any others as "output". Thus, with dedicated computer support, the field can be turned into a laboratory with which one can designate different initial conditions and examine alternative solutions.

GMA seeks to be integrative and to help discover new relationships or configurations. Importantly, it encourages the identification and investigation of boundary conditions, i.e. the limits and extremes of different parameters within the problem space. The method also has definite advantages for scientific communication and – notably – for group work. As a process, the method demands that parameters, conditions and the issues underlying these be clearly defined. Poorly defined concepts become immediately evident when they are cross-referenced and assessed for internal consistency. Like most methods dealing with complex social and organizational systems, GMA requires strong, experienced facilitation, an engaged group of subject specialists and a good deal of patience.

4. Outline for a Morphology of Theories of Emergence

The appropriate first step in realising Bailey's full 12-dimensional morphology would to reproduce his original 4-dimensional study using morphological procedures. Once this is done – whatever the results – we can go on to the full 12 dimensions.

First, let us take a look at what Bailey's 4-dimensional typology looks like in *morphological format* (Figure 4). As explained above, while the *typological format* embeds the four dimensions in 2-dimensional space (as in Figure 1), the morphological format represents dimension in form of a table-like field: the dimensions are given in the headings at the top of the field, and their respective attributes listed below them.

The advantage of the *typological format* is that every "type" (i.e. every 4-attribute configuration) has a unique *cell* which visually shows its relation to all of the other cells, and which can contain explanatory text. Thus the typology's basic structural information can be presented all-at-once in two dimensions. This is not the case in a morphological model: a *morphotype* is designated by selecting one attribute from each of the dimensions of the morphological field. Thus in order to display different (morpho-) types, and compare them, the model needs to be user-interactive: i.e. one needs to be able to select and compare different type-configurations. This interactive feature cannot be adequately represented "on paper". Only specific *examples* of type-configurations can be displayed, as seen in Figure 4, where we have selected a configuration corresponding to the Buckley, Mihata, Luhmann (BML) "Pattern Emergence" cell in Figure 1.

Nesting	Direction	Hierarchisation	OLD/NEW
Nested	Bottom Up	Hierarchal	New
Not Nested	Top Down	Non-hierarchal	Old

Figure 4. Bailey's 4-dimensional typology in GMA format with one configuration selected, representing BML "Pattern Emergence" from Figure 1.

Figure 5 shows the six dyadic (pair-wise) assessments (the light blue cells) required to define the "Pattern Emergence" configuration in Figure 4. However, in order to replicate Bailey's full 4-D typology in the form of a morphological inference model we must reverse engineer his whole typology. To do this we must carry out a consistency assessment on the total cross-consistency matrix in Figure 5 (i.e. 24 attribute pairs), identifying all pairs which are deemed logically or epistemologically inconsistent. Of the remaining pairs, we differentiate between those already theoretically acknowledged and those unacknowledged (unused), but consistent. Placed into proper GMA software, this will allow us to differentiate between configurations for currently formulated "theories", new possible theories, and internally inconsistent theories.

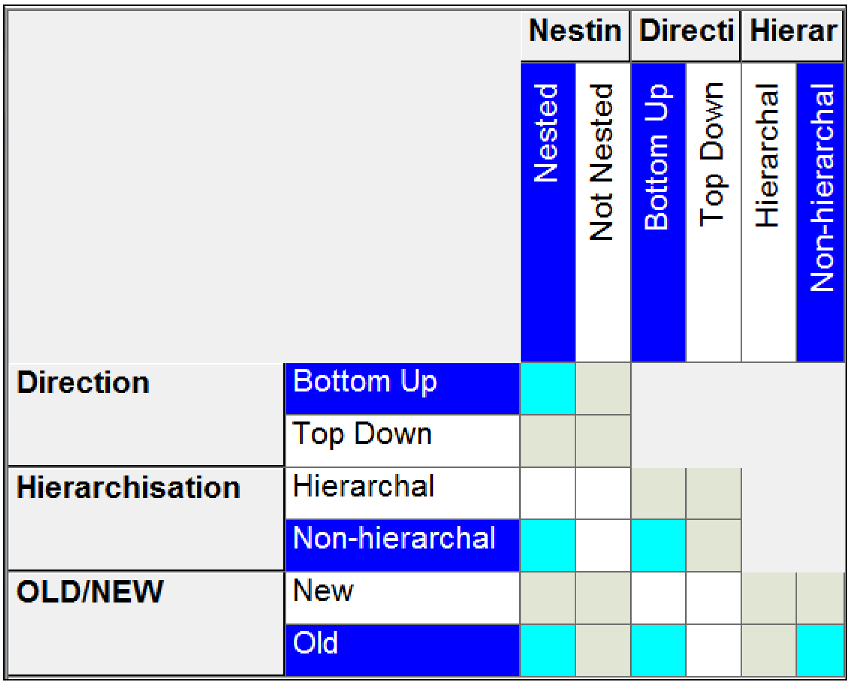


Figure 5. The Cross-Consistency pairs (marked in light blue) for the BML "Pattern emergence" configuration in figure 4.

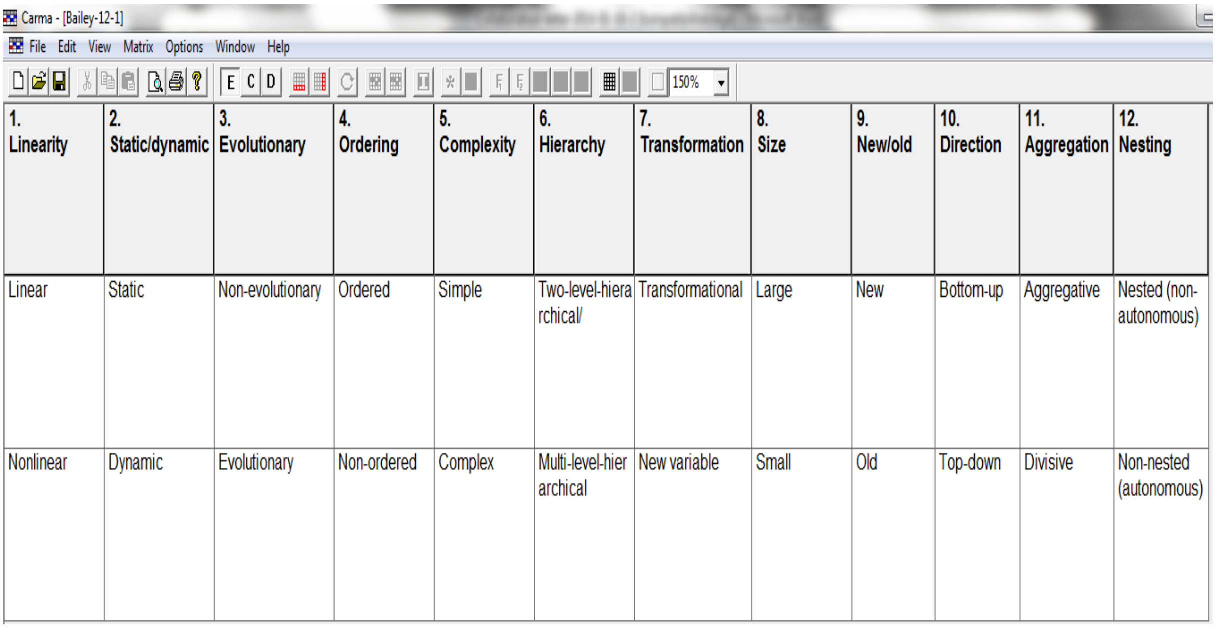
Moving from a typology of four binary parameters to one of 12 binary parameters entails moving from an outcome space of 2^4 =16 configurations to an outcome space of 2^{12} = 4096 configurations. It also involves moving from 24 to 264 cross-consistency assessments. Why would we want to take on such a task if we believe that we can identify certain collinear variables at the outset?

Since one of our objectives is to examine and compare a number of acknowledged *possible theories of emergence*, then systematically identifying and examining possible non-orthogonal dimensions derived from different theories should be seen as legitimate part of the morphological approach – i.e. it should show up in the model. Indeed, one of the advantages of GMA is that it liberates us from *enslavement to orthogonality*.

Furthermore, we wish to include suspected collinear parameters because different areas of science – e.g. physical, biological, social and cognitive – are confronted by emergence in different ways, at different levels of organisation and with seemingly different sets of laws. Since there is presently no general, integrated *trans-disciplinary* theory of emergence with an accepted common terminology and common modelling framework, we are wise to honour as many concepts as possible, and treat them in a single theoretical framework where they can be analysed and compared.

This does not mean that we are banned from merging parameters in different versions of emergence theory if we find them *obviously expressing the exact same concepts*. Also, there may be good reasons to *add* new dimensions, which do not seem to be explicitly represented in any present theory (see below).

In any event, there are advantages to using Bailey's original 12 parameters as the starting point of a collaborative meta-modelling effort, so that we do not have to start from scratch. Figure 6 shows the initially proposed morphological field of 12 dimensions. Figure 7 is its corresponding cross-consistency matrix, made up of 264 attribute pairs.



1. Linearity	2. Static/dynamic	3. Evolutionary	4. Ordering	5. Complexity	6. Hierarchy	7. Transformation	8. Size	9. New/old	10. Direction	11. Aggregation	12. Nesting
Linear	Static	Non-evolutionary	Ordered	Simple	Two-level-hierarchical/	Transformational	Large	New	Bottom-up	Aggregative	Nested (non-autonomous)
Nonlinear	Dynamic	Evolutionary	Non-ordered	Complex	Multi-level-hierarchical	New variable	Small	Old	Top-down	Divisive	Non-nested (autonomous)

Figure 6. The morphological field for Bailey's 12-D typology of emergence, generating 4096 possible *formal* configurations.

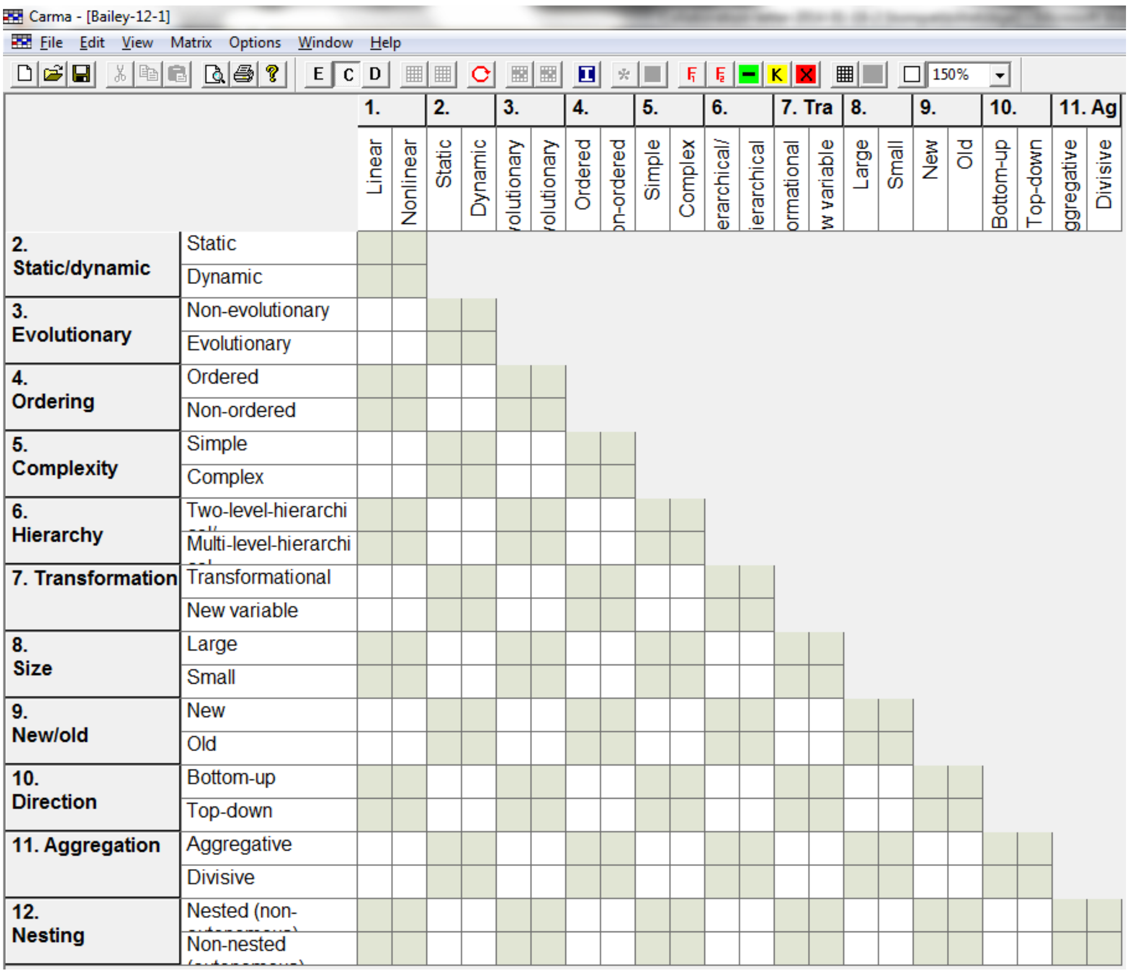


Figure 7. The cross-consistency matrix for Figure 6, with 264 pair-wise "assessments" in 66 parameter blocks (the white and shaded 2x2s).

There are a number of issues that need to be addressed upon initiating a full morphology:

1. Firstly, this work cries out for interdisciplinary collaboration. This is best done in a facilitated workshop setting where group interaction is a central feature of the process. This is because we are not only structuring a complex problem, but creating among the participants shared concepts and a common modelling framework. What is essentially a process of collective creativity is best facilitated in dialogue between participants. For this reason, we have found it best to work with subject specialist groups of no more than 6–7 persons. And here there is a problematic trade-off: is it possible for seven persons to represent an adequate knowledge base in order to accomplish the task?

2. A re-evaluation of Bailey's 12 parameters will be needed in order to re-establish and make explicit their meanings in different disciplinary contexts and in a way acceptable to a multi/trans-disciplinary group.

3. As concerns the pre-reduction of dimensions: we can do this when clearly warranted, but this time without methodological duress. We have *just cause* for a specific reduction when two parameters clearly represent or express identical attributes. This often happens when complex concepts are substructed from different disciplines or sub-disciplines, in which different terms are used for one and the same attribute. In this context, one of the important outcomes of developing a common modelling framework is the development of a common terminology which will allow for better communication between disciplines later on.

4. In approaching *emergence* from a multi/trans-disciplinary perspective, we may not only need to adjust the original parameters, but also expand them. An example is the explicit inclusion of the dimension of "weak" vs. "strong" emergence in the parameter list. Some have argued that this is not necessary, since it is claimed that any and all theories of emergence can be expressed in either way – i.e. that the weak/strong dimension lies totally outside of the problem. However, even a cursory look at Bailey's 12 parameters gives me the feeling that not all of the attributes – or at least combinations of attributes – are equally compatible with both weak and strong theories. The main point, however, is that this should be part of the modelling experiment, i.e. by including this and other relevant variables we will be able to demonstrate their "status" in this context.

5. It would be advantageous to re-dimension the *form* of the morphological field. The use of many binary dimensions is not the optimal way to apply GMA, as it creates too shallow a morphological field and makes it more difficult to visualise. Both for modelling technical reasons and, I think, for psychological reasons, it would be better to work with a 6 dimensional model consisting of 4 attributes under each parameter, than with a 12 dimensional model consisting of binary attributes. This is a purely methodological and facilitation issue and does not affect the substance of the results obtained.

As in the case of Bailey's paper, our task at this point is not to attempt find the "right" theory of emergence. By proposing a full morphology based on Bailey's 12 parameters, we wish to create a framework to systematically identify, exemplify and compare already existing theories within the framework of *all possible theories of emergence*. Hopefully such a meta-theoretical framework would help to better clarify different theoretical perspectives and create among researcher a better understand of their differing positions.

6. References and Further Reading

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