CHANGES IN SPATIAL SCALE AND THE INTERPLAY BETWEEN UNITY AND MULTITUDE IN GEORGES CHAPOUTHIER'S MOSAIC THEORY OF NATURAL COMPLEXITY

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Abstract. The paper argues that while the mechanism at the core of the mosaic theory is one of outstanding simplicity, the way in which it hinges on spatial scale change and the interplay between unity and multitude plays a key role for the ensuing structural and dynamic complexity. On the other hand, the relative autonomy of the units that are part of the system is critical to the mosaic theory, as it was to those discussed by world-changing thinkers such as Leibniz and Kant. The degree of this autonomy can be decisive for the mosaic-forming process and, in the end, for the resulting system. The model also includes surprising properties with respect to time. It is shown that the temporal characteristics of the basic operations can contribute to the resultant system's structural variability and diversity, as well as to adaptive complexity. Moreover, spatial observational scale detains a key to opening up the system history: producing changes in the value of scale is equivalent to moving backwards or forwards in time.
Keywords: mosaic theory, complexity, spatial scale, unity, multitude, time

ИЗМЕНЕНИЯ ПРОСТРАНСТВЕННОЙ ШКАЛЫ И ВЗАИМОДЕЙСТВИЯ МЕЖДУ ЕДИНСТВОМ И МНОЖЕСТВОМ В МОЗАИЧЕСКОЙ «ТЕОРИИ ЕСТЕСТВЕННОЙ СЛОЖНОСТИ» ДЖОРДЖА ЧАПОУТЬЕРА

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Резюме. В статье утверждается, что хотя механизм, положенный в основу мозаической теории и является выдающимся образом простым, но то, как он основывается на изменениях пространственного масштаба и взаимодействии между единством и множеством элементов системы – это играет ключевую роль в организации последующей структурной и динамической сложности. С другой стороны, относительная автономия единиц, входящих в систему, имеет решающее значение для мозаической теории, как и для тех случаев, которые обсуждались мировыми мыслителями, такими как Лейбниц и Кант. Степень этой автономии может быть решающей для процесса формирования мозаики и, в конечном итоге, для возникающей конечной системы. Модель также включает в себя удивительные свойства по времени. Показано, что временные характеристики основных операций могут способствовать структурной изменчивости и разнообразию результирующей системы, а также адаптивной сложности. Кроме того, пространственная наблюдательная шкала задерживает ключ к открытию истории системы: создание изменений в значении масштаба эквивалентно перемещению назад или вперед во времени.
Ключевые слова: мозаическая теория, сложность, пространственный масштаб, единство, множество, время

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The reader who opens "The Mosaic Theory of Natural Complexity. A Scientific and Philosophical Approach" by the neuroscientist and philosopher Georges Chapouthier (2018) is confronted with a quite astonishing statement: many categories of complex systems can be considered to emerge due to the repeated application of two successive operations – juxtaposition and integration, which leads to the production of a "mosaic" with particular properties. The goal of the book is thus unusually ambitious and brings to mind the small, but select set of scholarly works that have successfully attacked questions of such a caliber. Not only is the problem of the origin of complex systems, in general, notoriously elusive: the very notion of 'complexity' is far from being unanimously circumscribed – even less so is it consistently defined [Urry, 2005; Johnson, 2009][2]. How has it become possible then to extract and lay in front of the readers a simply defined two-step mechanism, meant to explain the origin of complex systems? It should be stated right from the beginning that this is indeed what the author did. To appease the readers who may have become by now particularly skeptical, we should also add that such a task was taken on before. One of the ways of making this undertaking less unthinkable consists of selectively focusing on certain categories of objects or phenomena, rather than trying to address in one explanation every situation ever related to complexity. Hence valuable insights have been gained into key aspects of a wide variety of complex systems; the criteria applied in the process of selective focusing bear labels such as[3] self-organized criticality [Bak, 1996], iterated function systems [Barnsley, 1988], critical phenomena [Sornette, 2000], dissipative structures and self-organization [Glansdorff and Prigogine, 1971; Nicolis and Prigogine, 1977], fractals [Mandelbrot, 1975], networks [Barabasi, 2003; Newman et al., 2006], chaos [Lorenz, 1996; Ruelle, 1989, 1993; Stewart, 1990; Waldrop, 1992] etc. In most cases the so-called selective focusing has operated in a way that has preserved an enormous diversity of applications, spanning a wide range of scales. This is also true about the mosaic theory. This is not the first time when the author discusses a mosaic dynamics perspective to decipher the landscape of complexity (see especially, [Chapouthier, 2001]). However, this book stands out due to its comprehensiveness (it spans a vast intellectual area, from biological cells and organs to memory, consciousness, philosophy, and even social structures), its clarity and elegant simplicity, and especially due to the fusing of these qualities in an ample yet condensed material.

Questions like the one underlying such a theory are truly exceptional. They bring to mind the uncommonness of the long awaited question, the wondrously awakening question, which was eventually asked in the legend of the Fisher King. Much like in that kingdom, those capable of asking "the question" are few; those who embark on the journey to further pursue it – even fewer. The discrepancy becomes

[2] In this paper, the term "complexity" is to be understood in relation to complex systems and the science of complexity, and not to computational complexity.

[3] In most cases the cited sources were selected to represent books that are accessible to the non-specialist rather than journal articles in which the mentioned achievements were first published. Where the goal was to highlight pioneering developments in a given direction, the earlier titles among those published were cited.

striking when one considers the scarcity of such adventurous attempts against the number of scholars working in complexity studies in various fields. Most specialists choose to engage in an effort to deepen our understanding of certain aspects of reality, often characterized by strong variability, challenging predictability, elusive paths of system transformation, etc. In contrast, to ask and address questions of all-pervading generality involves obstacles of a distinctive nature and unusual strength, and to succeed in such an adventure there is a need for an intellectual tension and internal resources which are rarely available.

A question like the one regarding the origin of complex systems operates on a different level compared to most other questions asked in science. Instead of referring to the origin of a certain object or phenomenon, it asks about the generating principles – not only the actual factors – but the principles at work, not in an object or in similar objects, but in a multitude of situations of a large variety, linked not by size, or shape, or another such property, but by an ensemble of features that bear the fingerprint of nothing less than complexity. The ensuing special category of explanation acts on an extensive interval of scales, from the microscopic to the macroscopic –and even the galactic – scale; it includes a large diversity of processes; it even goes beyond the search for a well-defined specific cause and considers a range of strikingly different causal factors; and under these circumstances, it eventually identifies principles that lead to the features distinguished in the structures and processes of interest. It is not surprising that such an accomplishment often has important implications on the methodological level: very different types of systems and/or phenomena can suddenly be successfully approached with the same or similar methodological instruments. The connection between strong variability (characterizing systems that are otherwise very different from each other) and the generation of powerful common methodologies for their analysis has been established a long time ago [Schertzer and Lovejoy, 1990]. A natural implication consisted of waves of new, widely applicable methodologies and effective, sometimes surprising applications [Bunde and Havlin, 1996; Hergarten, 2010; Meakin, 1998; Turcotte, 1997]. Given the seemingly unending series of areas in which the mosaic theory can be recognized, one should not be surprised if advances in the mathematical treatment of the model will be followed by numerous concrete applications as well.

The mosaic model includes two “basic operations”: (A) juxtaposition and (B) integration. Juxtaposition involves the multiplication and adjacent positioning of similar instances of the same element or “unit”. The resulting set of units is undifferentiated in terms of the role played by the individual units (the author offers examples of cell groups or birds lined up overnight). Integration attaches the set of elements generated by juxtaposition into another entity, which has a higher hierarchical level. For the novel, larger integrated entity, the assimilated set of virtually identical elements represents a distinct, single unit, so that the integration act can be considered to consist of one step. The phases A and B can keep succeeding each other repeatedly. Since phase B involves an interaction between two distinct types of unit (one created in phase A and one that precedes that phase, which is hierarchically superior to the assimilated unit), the A-B succession of processes increases the structural richness of the resulting entity, leading to a "mosaic" of fast growing complexity.

The image and the concept of a mosaic have been applied in philosophy, literature, etc. in many different ways. Schopenhauer discusses it repeatedly, both in his main work, "Die Welt als Wille und Anschauung" [Schopenhauer, 1844/1966[4]], and in his major supportive writings, "Parerga und Paralipomena" [Schopenhauer, 1851/1974]. He points out that the stone that constitutes a piece of the mosaic never dissolves in the image formed by the mosaic; its edges are always present and confer relative independence to the small part that contributes to the larger system. This statement is in agreement with the mosaic theory, according to which the subsystems, integrated as they may be, still enjoy a certain degree of autonomy; they can always be distinguished, structurally and functionally, from the rest of the system [Schopenhauer, 1844/1966:57]. Integration does not mean fusion. There is no melting inside the boundaries of the system. On the other hand, Schopenhauer draws attention to an important, albeit often neglected element of the act of observation: scale. It is by moving and changing scale, in fact by exploring a range of scales, that one may find the proper way to distinguish and understand the components involved in a certain hierarchic level of the studied structure [Schopenhauer 1851/1974:593].

One can reconsider this scenario from the perspective of its key terms. A relatively simple element, initially representing a *unity*, gets to multiply, being juxtaposed repeatedly, so that a *multitude* is formed. At some point this set is integrated into a hierarchically superior entity. In the integration process, the set of units previously seen as a *multitude* is suddenly itself treated like a *unity*, and attached, with relative autonomy, to the pre-existing integrating system. In other words, the key theme consists of an active interplay taking place in a variety of conditions between the unity and the multitude. One and the same building brick gets to play successively the important roles of unity and multitude. The relation between one and many is a topic with deep roots and a rich path in the history of human thinking, addressed by some of the planet's greatest philosophers, from Plato and Aristotle to Saint Thomas Aquinas, to Descartes, Locke, Berkeley, and Kant, … all the way to Cassirer, Gadamer, etc. What is it that a contemporary author can use today to have this age-old relation fresh and fruitful? Stated in one word: complexity. The relation between one and many lies at the core of the mosaic theory. One aspect that stands out regarding this relation in the new context is its elegant simplicity. Few thinkers have put to work the relation between one and many in a way that is so understandable and yet so deep and connected to other key thought processes. In compact form, the theory shows that one element can be subject to multiplication and then to integration in a new unit. The process continues: one becomes many - many become one - one becomes many... The simplicity of the process can be misleading. There are, in fact, several key aspects to this process which make it special. First of

[4] References specifying two different years refer first to the original writing/publication year, and next to the publication year of later editions, which are more easily available today. The number that follows the colon (if present) indicates the page number in the latter.

all, what seems to be a repetition is not. The components of the series subject to successive transformations are not the same ones in the different phases that follow each other. The "one" in the series is different every time it appears through a novel integration, being characterized by higher and higher complexity. It actually consists of a series of alternating states, which may look similar to each other, suggesting pervasive "being". However, while the "becoming" reveals the arrow of time in this succession, the "one" that emerges from "many" is not one and the same throughout the process: it becomes larger and larger, and increasingly complex. In many cases, the parts included in that unit, "the many", are still observable. To properly compare the system after integration to its pre-integration appearance one must shrink the former's image by a proper ratio. The scale change consistently performed after each integration step keeps the system at a steady size, but makes its structural similarity visible. Depending on the actual integration process the resulting configuration may have self-similarity properties, especially after a significant number of scale change operations. The actual system grows in size after each integration step applied to a group of juxtaposed elements: the observer can thus make the scale adjustment to the system image after each of these steps, and see a system that changes internally – increasing its complexity – while preserving its size. Alternatively, the observer can leave the system unchanged, and use observational scale change as an exploration instrument to delve into more and more details. By adjusting the exploration scale to notice finer and finer features, one moves further into the past. In other words, the change in scale becomes equivalent to a change in time. This way of operating upon spatial scale to move in time is a particularly interesting implication of the model in terms of research methodology.

When we call the ensemble "the one" we mainly do so because we *recognize* it as such, even if it is in some ways different from the one produced by earlier cycles, with sub-parts enjoying more or less autonomy. In other words, ontological aspects of the process of transformation are inter-weaved with epistemological ones. Material transformation alternates with informational transformation, the latter being involved in terms of structure or arrangement of the new unit. Being and becoming, one and many, ontology and epistemology, material vs. informational phases in the process, are all part of this apparently simple model.

One of the noteworthy properties of the model concerns the relationship between the units, their "relative autonomy". The degree of this autonomy can be decisive for the development process and, in the end, for the resulting system. This degree of autonomy is easier to distinguish and evaluate in some systems (such as biological cells in an organ) than in others (many of the innumerable applications of the mosaic theory). The problem of the nature and degree of the relative independence enjoyed by parts in an ensemble is not new, and centuries-old perspectives can prove to be viable and helpful. Leibniz considered the problem from many angles, and he found nuanced solutions [Lodge, 2001]. Of particular interest is his observation that the parts in what he calls an "aggregate" may have different degrees of autonomy. Moreover, it is the extrinsic unity, rather than the intrinsic one, which dominates. He assigns to the nature of the ensemble a significant epistemic component, as he points out that the aggregate acquires its status of unity due to the fact that it is seen and recognized as such. Unity is coming "from the mind". However, this does not happen arbitrarily, but based on recognized properties that the parts actually do have in common [Leibniz, 1703/2010:256]. Likewise, Kant almost seems to refer precisely to the mosaic model when, discussing space, he states that the parts that form an aggregate are not subordinated to each other, but co-ordinated with one another [Kant 1781/2007:A413], which evokes an organic nature of the links among the parts in the model.

The essence of the proposed model is recognized and discussed in numerous domains, from genetics and processes at the molecular level to aspects of human brain development, memory, drawing, literature and music, and to social structures and ethics. Topics such as animal "protocultures" and the relationship between nature and culture are addressed in thought-provoking ways. The Aristotelian background of this intellectual edifice is consistently considered and often made clearly visible. In a philosophically surprising feat, the dynamics of the mosaic theory is connected to the dialectical process, and revealed as the inner engine of the latter. From here, it took only one step to connect to Khroutski's Biocosmological theory with its deep Aristotelian basis, its key concept of Triunity, and its wide-ranging implications [Khroutski, 2013]: this is accomplished in a way that proves once more the capacity of the model to approach the essence of a large spectrum of phenomena, and to detect and relate to congruent thinking patterns, even when such congruence is not obvious in the beginning.

It is possible to follow the implications of the described mechanisms beyond the limits discussed in the text, which is a sign of a ripe theory. One may note, for instance, that the described processes might not have to follow a strict temporal order. This idea may initially sound confusing, because the description of the structure-generating mechanism is supposed to involve clearly delimited time steps. The two processes, however, can and should be distinguished in terms of the actions they perform, rather than by the time intervals over which such actions actually take place. For instance, process A, juxtaposition, may and often does continue to occur even after the integration phase, B, has taken place. What one must keep in mind when analyzing the complexity-bearing mechanisms is the type of action that is performed in the various areas of the system and at certain points in time. Interestingly, however, the mere occurring of processes A and B introduces constraints that affect the development of those processes in the future. Therefore, the temporal arrow is present, even if both types of processes A and B can (and sometimes do) take place in an intermingled way, i.e. one of the processes may start before the alternate process is finalized. To return to the example in which multiplication/juxtaposition can still take place even after integration, the potential number of multiplied entities, as well as the choices for their possible spatial locations are limited and determined by the way in which the integration has taken place. Such interdependencies may lead to a less clear-cut juxtaposition of former "units" and to enhanced complexity. Moreover, structural constraints are expected to be associated with functional constraints as well. Thereby, although they start from what looks like mere geometric building block criteria, the specified processes can lead to increasingly well adapted, sophisticated features, capable of optimizing their structure and behavior. In other words, the model is not confined to an exact repetition of algorithms: it allows for both spatial and temporal variability to be included in the resulting structure. Rigid determinism is thereby overcome, leaving room for the flowering of adaptive processes and structural variety One of the points of beauty of the theory consists precisely in this quality of putting to work deep-lying, key principles of complex systems: the mechanism consists of an apparently simple succession of two clear-cut phases, and yet it can lead – due to repetition, inter-conditioning and encapsulated feedback loops – to features that are characterized by fast growing and effectively adaptive complexity.

References

Bak, P., *How Nature Works: The Science of Self-organized Criticality*. New York: Copernicus, 1996.

Barabasi, A.L., *Linked*. New York: Plume Books, 2003.

Barnsley, M., *Fractals Everywhere*. Cambridge, MA: Academic Press, 1988.

Bunde, A., Havlin, S. (eds.), *Fractals and Disordered Systems*. New York: Springer, 1996.

Chapouthier, G., *L'Homme, ce singe en mosaïque*. Paris: Éditions Odile Jacob, 2001.

Chapouthier, G., *The Mosaic Theory of Natural Complexity. A Scientific and Philosophical Approach*, Paris: Éditions des maisons des sciences de l'homme associées, 2018.

Feder, J., *Fractals*. New York: Plenum, 1988.

Glansdorff, P., Prigogine, I., *Thermodynamic Theory of Structure, Stability, and Fluctuations*. London: Wiley-Interscience, 1971.

Hergarten, S., *Self-Organized Criticality in Earth Systems*. New York: Springer, 2010.

Johnson, N. F., *Simply Complexity: A Clear Guide to Complexity Theory*. London: Oneworld Publications, 2009.

Kant, I., *Critique of Pure Reason*. Transl. by M.Weigelt, London: Penguin Books, 2007.

Khroutski, K., Forming an evolutionary vector to the Aristotelian pole of scientific organicism (Biocosmology), *Biocosmology-Neo-Aristotelism*, 3(1):28-51, 2013.

Leibniz, G.W., *Die philosophischen Schriften von G. W. Leibniz.* Vol. 2. Ed. by C.I. Gerhardt, Charleston: Nabu Press, 2010.

Lodge, P., Leibniz' notion of an aggregate. *British Journal for the History of Philosophy*, 9(3), 2001: 467–48.

Lorenz, E., *The Essence of Chaos*. Seattle: University of Washington Press, 1996.

Mandelbrot, B.B., *Les objets fractals: forme, hasard et dimension*. Paris: Masson, 1975.

Meakin, P., *Fractals, Scaling and Growth Far from Equilibrium*. Cambridge: Cambridge University press, 1998.

Newman, M., Barabasi, A.L., Watts, D.J. (eds), *The Structure and Dynamics of Networks*. Princeton: Princeton University Press, 2006.

Nicolis, G., Prigogine, I., *Self-Organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations*. London: Wiley, 1977.

Ruelle, D., *Chance and Chaos*. Princeton: Princeton University Press, 1993.

Ruelle, D., *Chaotic Evolution and Strange Attractors*. Cambridge: Cambridge University Press, 1989.

Schertzer, D., Lovejoy, S., *Hard and Soft Multifractal Processes*, Physica A 185: 187–94, 1992.

Schopenhauer, A., *The World as Will and Representation*. Transl. by E.F.J.Payne, Vol. 1, New York: Dover Publications, 1966.

Schopenhauer, A., *Parerga and Paralipomena*. Transl. by E.F.J.Payne, Oxford: Clarendon Press, 1974.

Sornette, D., *Critical Phenomena in Natural Sciences: Chaos, Fractals, Selforganization and Disorder: Concepts and Tools*. Berlin: Springer, 2000.

Stewart, I., *Does God Play Dice? The Mathematics of Chaos*. Oxford: Blackwell Publishers, 1990.

Turcotte, D.L., *Fractals and Chaos in Geology and Geophysics*. Cambridge: Cambridge University Press, 1997.

Urry, J. (ed.), *Complexity*, Special Issue of *Theory, Culture & Society*, 22(5), SAGE, 2005.

Waldrop, M.M., *Complexity : The Emerging Science at the Edge of Order and Chaos*. New York: Simon & Schuster, 1992.