Mosaic Model: An integral approach towards understanding development and process of the human brain

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Мозаическая модель: Интегральный подход к пониманию развития и процессов человеческого мозга

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Abstract. The idea of cosmic and biological self-organisation with continuity as depicted in human neuroanatomy underlies the Biocosmological theorising carried out by the researchers of the Biocosmological Association, and which aligns with the universal scientific paradigm developed by Aristotle. The Stagirite was also interested in the structure and function in biological organisms. His rigorous biological investigation was central in developing the scientific method – foundational to the life sciences. Aristotle's interest with form and function of natural organisms serves as a trajectory for my examination into the human brain. I argue that the human brain can be understood according to organisational patterns at micro and macro levels of cerebral architecture. In order to further explain this idea, I incorporate the Mosaic Model developed by Georges Chapouthier, which provides a relevant theoretical approach identifying and understanding structure and complexity of living systems.

Keywords: biological life, complexity, cerebral development, cytoarchitecture. Aristotle's Biology

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Резюме. Идея космической и биологической самоорганизации с преемственной последовательностью (непрерывностью), как это отображено в нейроанатомии человека, лежит в основе Биокосмологического теоретизирования, осуществляемого исследователями Биокосмологической ассоциации; и что реализуется в тесной связи с универсальной научной парадигмой реального мира, разработанной Аристотелем. Стагирит также интересовался структурой и функцией биологических организмов. Его тщательное биологическое исследование сыграло центральную роль в разработке научного метода, лежащего в основе наук о жизни. Интерес Аристотеля к форме и функциям природных организмов служит траекторией моего исследования человеческого мозга. Я утверждаю, что человеческий мозг можно понять в соответствии с организационными паттернами на микро- и макроуровнях мозговой архитектуры. Для дальнейшего пояснения этой идеи я использую Мозаическую модель, разработанную Жоржем Шапутье, которая обеспечивает соответствующий теоретический подход к выявлению и пониманию структуры и сложности живых систем.

Ключевые слова: биологическая жизнь, сложность, мозговое развитие, цитоархитектура, биология Аристотеля.

Содержание

Introduction. The human brain is not a computer. This point has to be made clear from the start. As an evolutionist, correlating the human brain to machines is not only a bad idea, but overlooks its immense neuro-hormonal complexity. Although, our knowledge of the brain has increased over the last few decades, it is still inadequate in explaining how thoughts or consciousness arise. The human brain is a complex evolutionary organism whose biology reflects universal processes. Yes, the underlying neuroanatomical structures of the human brain reflect cosmological principles. This is the crux of my thesis which I will briefly elaborate.

The idea of cosmic and biological self-organisation has been foundational to the Biocosmological Association and personally the scholar Konstantin Khroutski, whose theorising is correlative with Aristotle. He and other Greek natural philosopher scientists were preoccupied with understanding natural forms. For example, Pythagoras of Samos (circa 570 BC) conjectured a relationship between numbers and nature, culminating in his theory of musical scales as based on numerical ratios – a brilliant thesis. Anaximander of Miletus (c. 610 BC) proposed that terrestrial forms derived from the oceans under a process of evolution. His speculation was correct. Furthermore, Democritus of Abdera (460 –370 BC) hypothesised that matter was composed of indivisible particles – atoms, which constantly moved in space. The Greeks were also drawn to symmetry and harmony when applied to natural forms [Lloyd, 2010].

Aristotle was further interested in the structure and function in biological organisms. Consequently, his inquiry of animal structures led to him dissecting many types of animals. This kind of biological investigation was significant in developing the scientific method – foundational to the life and physical sciences. Aristotle's fascination with form and function of natural organisms serves as a trajectory for my examination into the human brain. I argue that the human brain can be understood according to organisational patterns at micro and macro levels of cerebral architecture. In order to further unpack this idea, I incorporate the Mosaic Model which provides a relevant theoretical approach when examining structure and complexity of living systems.

1. Mosaic model: A theoretical overview

The Mosaic Model developed by the neuroscientist and philosopher Georges Chapouthier [2018] who hypothesises that anatomical structures are based on the processes of *juxtaposition* and *integration*. Chapouthier borrows from Aristotle's notion that the cosmos is built in a biological manner. In other words, the elements of the universe are predicated according to organic principles that produce life. Consequently, awareness of those laws which govern complex living organisms provide a method for studying complexity [Chapouthier, 2018, p. 49).

In juxtaposition molecular and cellular units are arranged in beadlike formation. During integration these units undergo modification and refinement in order to create new higher order structures. What is important here is that each unit is interdependent; cooperating with other units while conserving its unique autonomy. Volk and Bloom (2007, p. 29), elegantly suggest this as follows:

> *Biological evolution is a pattern-finding process, on various scales, both spatial and temporal, and the patterns that have been evolved can be similar across diverse and independent instances.*

Similarly, the philosopher Daniel Dennett [1995], notes that evolution has algorithmic elements, consisting of replication, variation, and selection. The iteration of these elements produce operational patterns in biological and social structures. For Chapouthier, replication produces juxtaposition and integration generates variation. The crux of the Mosaic Model is that increasing complexity arises from the congregation of lower level units in novel arrangements [Mazzocchi, 2010, p. 342]. A key element of Chapouthier's system is predicated on the inter-dependency of mosaic structures, which increase organisational efficiency and reduce entropy in multicellular organisms. Here, Chapouthier [2018, p. 6], further employs Aristotle's dictum on the integrity of *holons* – complex structures that at their basic components retain autonomy, while maintaining the integrity of the whole. Thus, self-assemblage regulates mosaic processes towards greater complexity. The *telos* of living organisms is that they maintain integration at every level. Consequently, biological structures operate within the ambit of dynamic equilibrium.

The idea of self-assembling mosaic structures is reminiscent of Gregory Bateson's "ecology of mind" - a collective of units of a system. These integrated components are characterised by symmetrical and iterative patterns, and are inherent to all biological and social systems [Bateson, 1971]. In nature, mosaic patterns are informed by archetypical patterns called meta-patterns – "a pattern of patterns" [Bateson, 2002].

In nature the principles of self-assembly of organisms as depicted in the Mosaic Model can be traced back to the origins of the cosmos. For example, in the infinitismal moments of the singularity inflationary event ("Big Bang") approximately 13.7 billion years ago, particles such as quarks were created. Three minutes after the Big Bang the nuclei of hydrogen, helium, beryllium and lithium were formed. It took approximately a third of a million years after the Big Bang for the first atoms to appear. Hundreds of millions of years after the Big Bang, the first stars were formed. Thus, the juxtaposition of atoms became integrated to form self-regulating, self-organising open systems. Biological life on earth embodies the organisational patterns of the cosmos. Like stars, biological organisms are open systems and generate their own energy from the breakdown of entropy. Indeed, a hallmark of life has been its ability to reduce entropy processes in order to maintain homeostasis.

2. Development of the Human Brain

In species such as *H. sapiens*, homeostatic control is facilitated by a complex central nervous system. From an embryological viewpoint the human brain embodies mosaic principles. The brain forms from a neural tube in the 3rd-4th week of life. From the neural tube three primary ovoid vesicles are formed – prosencephalon, metencephalon, rhombencephalon. In the 5th week post-conception, five secondary vesicles derive from the three primary vesicles, thus, forming the entire cerebrum (figure 1).

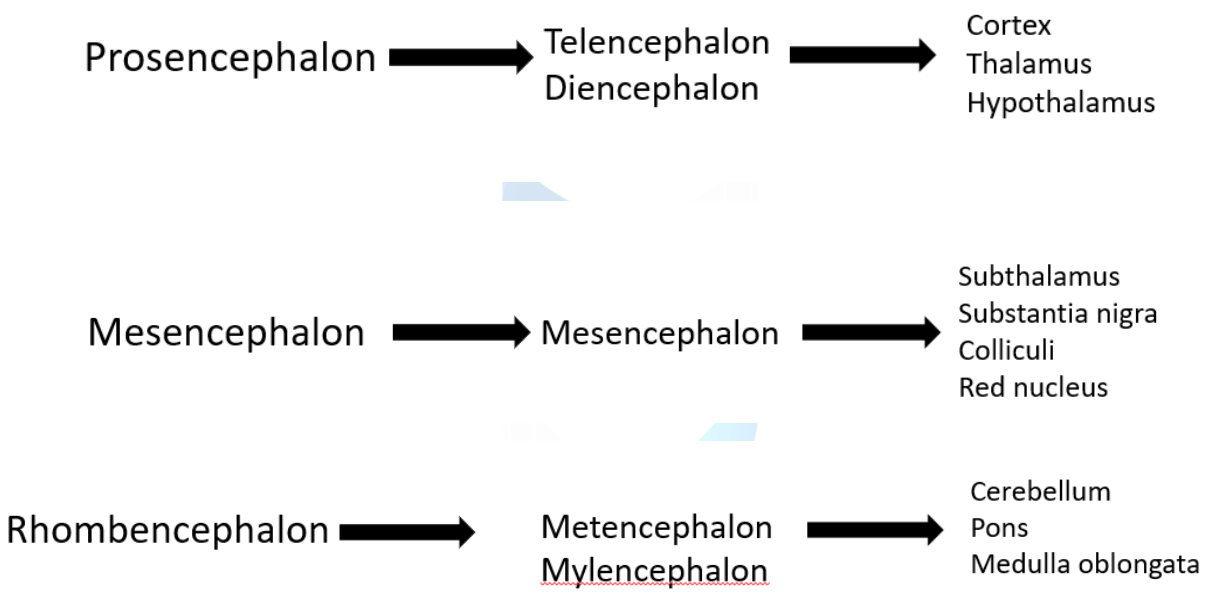

figure 1

I would now like to draw your attention to the two cerebral hemispheres which are composed mostly of white matter with a six-layer cell covering of grey matter (neocortex). Various authors proffer different estimates of neurons in the cerebral cortex. While older estimates revealed that the cerebral cortex consisted of approximately 7 billion neurons in the telencephalon [Sharif, 1953, p. 398], recent studies have modified that number to approximately 49.3 billion neo-cortical neurons in females and 65.2 neo-cortical neurons in males [Pelvig et al, 2008, p. 761), with the cerebellum consisting of over 100 billion neurons [Anderson et al, 1992, p. 558].

Glial cells which provide support, protection and nourishment to neurons far outnumber them in the cerebrum by approximately ten times [Pakkenberg and Gundersen, 1988, p. 8]. The dendritic anatomy

of each neuron allows it to receive the transmissions of thousands of other neurons. The totality of neural synaptic connections in the brain is approximately five hundred trillion – an incredibly vast synaptic matrix which confers to *homo* high order cognitive abilities and reflexive consciousness. The left and right cerebral hemispheres are ovoid shaped and are covered by *gyri* (prominences) and *sulci* (depressions). The highly folded appearance of the hemispheres allows for greater surface area. Interestingly, the convoluted architecture of the cerebral hemispheres, if altered, can lead to neurological pathologies [Gerritsen, 2013, p. 2]. Alternately, one study revealed "altered gyrification of the (right) anterior dorsal insula" of Zen meditators which may have increased synchronisation between cortical and limbic regions. The insula assists in emotional, cognitive and autonomic integration and awareness [Luders et al, 2012, p. 1]. Thus, experienced meditators showed greater emotional and impulse control and ability to reduce the default mode network (DMN) [Luders et al, 2012, p. 5].

The cerebral hemispheres are separated by a deep fissure – the great longitudinal fissure; this fissure contains the meningeal *falx cerebri*. The left and right cerebral hemispheres are connected by the *corpus callosum* – the largest of the commissural fibre pathways, consisting of millions axons. It is via the *corpus callosum* that connects homotypical regions of each hemisphere. The anatomical significance of the *corpus callosum* is evident in individuals whose *corpus callosum* has been damaged, causing them to have perceptual and cognitive difficulties. Each cerebral hemisphere is somatotopically arranged and provides motor and somatosensory innervation to the contralateral side of the body.

3. Cortical Cytoarchitecture manifests mosaic principles

I would like to turn our attention to cortical cytoarchitecture. As neuroscience posits, the human neocortex is six layered and approximately 2.5mm thick [Fischl and Dale, 2000, p. 1050]. These layers are arranged according to adjacent and interconnected columns. A column is a variation of a cube which is based on the square. In sacred geometry the square represents the four cardinal points, the four humours, the four seasons, and material existence. From the square is produced the square root of 2; the right angle axes produce replication, juxtaposition and integration. This is manifested by square grid patterns which may continue to infinity. The tightly packed columnar based neuroanatomy of the neocortex has been suggested to increase interconnectivity and integration between multiple neuronal columns. For instance, when observing an object, each neuronal column accesses only a limited amount of information of the object. It is only through the collaboration of multiple neuronal columns that a consensus of the observed object can is reached [Hawkins et al,

2017, p. 2]. Thus, each column is both autonomous and interdependent with other columns; each column involves itself with understanding the phenomenal world. However, multi columnar neural integration may act in resolving ambiguity [Hawkins et al, 2017, p. 12]. Some cells within a neuronal column respond only to stimuli on the horizontal plane along a single orientated axis. Thus, it seems that the neuronal level of organisation of the brain is not only mosaically organised, but that its internal organisation innately apperceives the world in a mosaic way [Lima-de-Faria, 2014].

4. Rehabilitating Aristotelian *Organon*Kosmology and the Cosmic Play of life

Human brain processes and dynamic complexity can be best understood in relation to Aristotelian *Organon*Kosmology, which is predicated on a set of elegant, and often misunderstood concepts such as *entelecheia*, *organon*, *hyle*, *dynamis*, *morphe*, *genos*, and others (Konstantin Khroutski and Milana Tasić 2021). For example, the brain is continually evolving and is ever in a state of structural and neuro-hormonal flux. Second, the brain closely follows the principle of self-organisation, combining Aristotelian concepts of *energeia* and *dynamis* in order to maintain its integral structure and function. Therefore, the brain is a constant potentiality to act (entelechy), which is central to its "natural evolutionary" course.

The *telos* of the human brain is that it is irreducible – it cannot be constrained by Platonic essentialism. Elsewhere, Saniotis and Henneberg (2013) have stated that life should be considered as being cybernetic due to its irreducible nature – thereby confirming Aristotle's dictum that the total is not merely the sum of its parts. Unfortunately, science's current "love affair" with biological reductionism can only promote a distorted view of biological systems. As Saniotis and Henneberg (2013) have argued, biological processes must be considered according to their various levels of relationality and multi-linear and incessant flows of information interacting kaleidoscopically in real time (Bateson 1972, Laszlo 2004). At this level, life becomes totally nonsensical in its sheer capabilities and levels of *poiesis* – which in Aristotelian terms means that entelechy is always fluid and unending in its potentialities and creative playfulness; a ludic play of cosmic proportions.

Recently, Khroutski and Tasić (2021) have made an elegant case for the rehabilitation of Aristotle's *Organon*Kosmology. Their erudite argument maintains that science needs to reformulate Aristotle due to historic and unending misinterpretation of his central concepts. This has had the effect of diminishing Aristotle's insight of the life sciences, with the subsequent effect of leveraging essentialist narratives. Second, Aristotle's *Organon*Kosmology highlights the integral nature of the cosmos, as explained earlier, while cleverly combining natural and cultural 'semiospheres' to coin

Makolkin (2020). This integral feature of cultural and natural lifeworlds has been taken up by Chapouthier's Mosaic model, which draws similarities between them. This biological way of understanding cultural systems, albeit, not novel (the early 20th century structural functionalist Emile Durkheim had envisaged society as operating like a multicellular organism), does nonetheless highlight the endearing influence of Aristotelian organicist philosophy.

Conclusion. In Hindu cosmology the universe was conceptualised as an infinite net, referred to as the "Net of Indra". At each vertex there was a translucent and multi-faceted jewel. It is believed that anyone who gazed within any jewel would perceive its reflection in all other jewels in the cosmic net. While this story has been traditionally interpreted in Buddhist philosophy as symbolising *pratītyasamutpāda* (interconnectedness and interdependency) and *śūnyatā* (emptiness), it alludes to the unity of cosmic and biological evolution. That is, if the universe is governed by general laws, then such laws must also apply to biological organisms by reason that biological evolution on earth is a continuation of cosmic evolution. Hence, the universe is constructed in a biological manner which concurs with Aristotle's bio-organic model.

Although, the shape of the human brain is genetically determined, it is by virtue of its complex geometrical patterning, intrinsic to its structures, which facilitates its impressive cognitive and imaginative abilities. Not only does anatomy inform structure and function, but the way in which structures form patterns which maintain the brain's neurodynamics. The Mosaic Model is pertinent to understanding the relationship between structure, pattern and function. Our current understanding of the human brain, albeit impressive, is far from complete. However, the use of systems approaches like the Mosaic Model can offer a more integrated explanation for understanding brain structure and complexity.

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