



## The Effect of Neuroscience on the Formation of Biodigital Space

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### Abstract

Studies in the rapidly developing neuroscience field in the early 21st century provide knowledge about the sensory stimuli the body receives from the environment. From a neurobiological perspective, loops and feedback are interconnected in the brain with matching internal sensory and motor maps. Neuroscience can help architects and neuroscientists design future spaces by interpreting experience and spatial transformation. Through neuroscience principles, space's network structure can be explored. It can enable the space, having a network structure, to transmit dynamically in its structural system. In this research, space's possibility as a self-generating system is examined through autopoiesis, explaining organismic body and life formation concepts. Establishing a relationship between the reproduction life parameters and space design by coding knowledge through digital experiments is aimed since life, vitality, and evolution are code sets. Space understanding with the organismic body increases its sensitivity and offers an opportunity for a re-discussion of space understanding.

**Keywords:** Architectural design, neuroscience, connective integrity, biodigital formation, autopoiesis.

## Biodijital Mekân Oluşumunda Nörobilimin Etkisi

### Öz

21. yüzyılın başlarında hızla gelişen sinirbilim alanındaki çalışmalar, vücudun çevreden aldığı duyuşsal uyarımlar hakkında bilgi vermektedir. Nörobiyolojik bakış açısında, döngüler ve geri bildirimler beyinde, eşleşen iç duyuşsal ve motor haritalar ile birbirine bağlıdır. Deneyim ve mekânsal dönüşüm alanlarını sinirbilim ilkeleri üzerinden yorumlamak, gelecekteki mekân tasarımlarında nörobilim ve mimari arasında işbirliklerine olanak sağlar. Nörobilimden öğrenilen ilkeler sayesinde mekânın ağ yapısı keşfedilebilir. Bunun dâhilinde bir ağ yapısına sahip olan mekânında, kendi yapısal sisteminde devingen olarak bir iletim yapabilmesine olanak sağlayabilir. Bu çalışmada, mekânın kendini üreten bir sistem olmasının olasılıkları, organizmik beden anlayışı, canlılığın oluşumunu açıklayan otopoiesis kavramı üzerinden incelenmektedir. Çünkü yaşam, canlılık ve evrimde kodlamalar bütünüdür. Organizmik beden ile birlikte bir mekân anlayışı, duyarlılığını artırarak gelecekteki mekân anlayışının yeniden tartışılması için bir fırsat sunmaktadır.

**Anahtar kelimeler:** Duyuşsal kodlama, nörobilim, bağlantı bütünsellik, biyodijital oluşum, otopoiesis.

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## **1. Introduction**

There is a need for change throughout life. Change happens through the transformation of a thing. These changes are neither temporary nor can they be spatially isolated. The changes are like a sequential chain, constantly evolving because life itself is precisely changing. The organism is one of the most important representations of transcending space. An organism needs to change independently of its form in order to survive. Organisms must necessarily be part of a cycle that includes a cellular phase, according to the logic of the formation of the changed entity. Because the most basic element is the cell, and with the cell, togetherness exists. It creates a unique communication code that organisms establish with the cells within them. Cells recognize each other by this unique code. Each communication and coding that the organism establishes affects the cells within its system. By modifying these unique codes, the organism, and hence the cells, becomes a more responsive dynamic context in the event of a problem. Due to the bidirectional dialogue that organisms establish with the environment in order to survive, it works like a homeostatic system, ensuring the continuity and change of the organism over time (Maturana & Varela, 2020).

Maturana describes the organism as an autonomous system. Autonomous systems are systems that are capable of self-management and self-regulation. The organism is also an autonomous system with the ability to control its vital activities such as self-nutrition, growth, reproduction, and homeostasis. According to Maturana, the organism functions as a system that maintains and sustains its structure by interacting with the external world. Since the organism is constantly interacting with external stimuli, it can reconstruct itself to adapt to changing internal and external conditions. Also, Maturana relates the organism not only as a biological system but also to knowledge processing and learning processes. The organism's knowledge of the environment is constantly based on stimuli and the organism's own experiences. Therefore, the organism is capable of self-learning and development by not only receiving knowledge but also interpreting and reconstructing it. When this homeostatic equilibrium state is disrupted by environmental changes, the organism goes through an adaptation process to achieve a new equilibrium state (Maturana & Varela, 2020). The body is where the most changes occur in organisms. In the body, the brain is the place where the factors of change occur most. The biological definition of the brain is not that it is a thinking machine; rather, it receives knowledge and begins to process it. The 100 billion neural networks in the brain are connected to each other with connective integrity (Kılıç, 2019). From a neurobiological perspective, the brain is seen as a dynamic central system where loops, feedback, and matching internal sensory-motor maps are interconnectional. Neurons, which constitute the dynamics of the central system, have a communication network that is covered by the connective integrity of 100 billion neural networks (Kılıç, 2019). The connective integrity relationship enables sensory communication to occur and also ensures that this communication continues dynamically (Kılıç, 2019). It shows that the autonomous structures of organisms and the relations of these structures with their environment contribute to the formation of the organism's connective integrity. The self-regulatory structure of the organism can cause the organism to reorganize its internal structure by changing relations with its environment. This process means that changes in the structure of the organism can influence its behavior, thus further strengthening the connective integrity between the organism and its environment (Maturana & Varela, 2020). Consciousness and mind are created by the sensory communication system, which is cyclical. The biological foundations of the formation of mind and consciousness are also grounded in organizational concepts such as Maturana's theory of autopoiesis. Maturana's organizational approach suggests that the formation of mind and consciousness is not just a phenomenon within the brain or nervous system. It is the mental process that takes place in all possible relations of all interactions within the organismic integrity. At the end of this process, consciousness is introduced as a value (Maturana & Varela, 2020). Consciousness values are formed only by the patterns they create and follow in a single moment. The same pattern does not occur in the next moment. This results in the creation of multiple coded consciousnesses. As a result, a neuro mind is formed in each consciousness. Each neuro mind selects a new pattern, resulting in the formation of a new communication network. Each communication generates thought and meaning, which in turn generates more communication. The mind becomes self-existent in this way. With the knowledge that the body processes in space, it

creates new patterns and layers. Space creates its mind with the consciousness it creates through the body because all life is a harmony of codes that exist intertwined. Each code morphs into the other. The body produces itself in every space by processing the connectivity that integrates with itself. The body gives space to its existence. The body's experiences in space alter space. The body gains new experiences as it moves through the changing space. There can be no separation of body and space. Because the body gives meaning to space. Space produces the network that it is meaningful to, and it is through this network that the mind comes into being. In neuroscience, the mind is not produced as a self-created connectivity network. The mind is the result of a connectivity network that occurs after the body interacts with life (Kılıç, 2019). What is called the mind is not the neuronal network in the physical organ we call the brain, but the name of the modeling created and produced by that neuronal network. In this respect, the mind can produce in space, within the interactions between the body and the environment, because space establishes a production dynamism thanks to its knowledge parameters with the body-environment. Each knowledge parameter that enters space forms a relationship with the space's network structure and generates a new network. The interaction between space and life results in the formation of new networks. The relationship between space and life is cyclical and ever-productive because space is life. And life exists in the midst of all the paradigms that surround it.

## **2. Material and Method**

Within the scope of this research, a literature review will be conducted first, followed by an examination of the concepts of space, embodiment, autopoiesis, and neuroscience as they relate to the formation of biodigital space. Based on the concepts and theories examined, a relational research method will be used. Instead of looking for a cause-and-effect relationship, the relational research method examines the correlation between variables that are affected in a variety of contexts. Within the scope of the literature study, the first relationship between space and body will be examined through information and network systems, and a new relationship context will be established through the brain's network system. The second relationship is to examine the context established between space and the organism's organizational system that ensures its survival. The requirements of the organizational system of an organism will provide information on how to establish the biodigital formation of space. Third, the relationship discussed, the sensible coding of the space, the effects of the network connectivity of the space, and the formation of the artificial life of the space were examined. This situation will be examined through Lary Spuybroek's Son –O–House project, and explanatory information will be provided about the context of all the relations established in the space. Finally, all the concepts examined will be conveyed through the simulation experiment study through the autopoietic behavior of the space and the biodigital formation of the space. Diagram studies were conducted to understand the concepts obtained from the literature review and the relationships established between these concepts. The study will conclude with an experiment in which the formation of the biodigital space will be seen as a result of all the data obtained.

## **3. Theoretical Framework**

### **3.1. Network**

The fact that the space has a knowledge-based formation allows it to receive and reproduce codes from the body in its relationship with the body, thus allowing its fluidity to continue. This situation allows knowledge to exist as an informational process in the layered structure of space. The process of becoming informed can only be realized by dynamically affecting both sides of the phenomenon being examined and the basic properties of a thing and the rules governing it (Arıdağ, 2018).

The fact that both the body and the space have a layered structure creates a meaning between the space and the body, which is intertwined and exists by complementing each other. This meaning indicates a network parameter. This network is similar to the connectivity network that provides the electrical transmission between nerves in the brain. The network of connective integrity is a knowledge communication network that belongs to life, where the network structures (network) that make it up create themselves and where each whole is part of a higher whole (Kılıç, 2020). It is a system of thought that not only remains in the field of neuroscience but also has the potential to affect all layers of culture

and architecture according to nature, and people's perceptions. Connective integrity is a modeling of life, a new configuration of mind (Figure 1). According to the understanding of connective integrity, the most competent, vast, and complex knowledge-processing networked structure is life itself. Space also contains life in its layered and dimensional structure. It creates this life with the connectivity of the spiral network paradigms it has established with the body. Because everything exists with the network in which it exists and is formed by it and constitutes it.

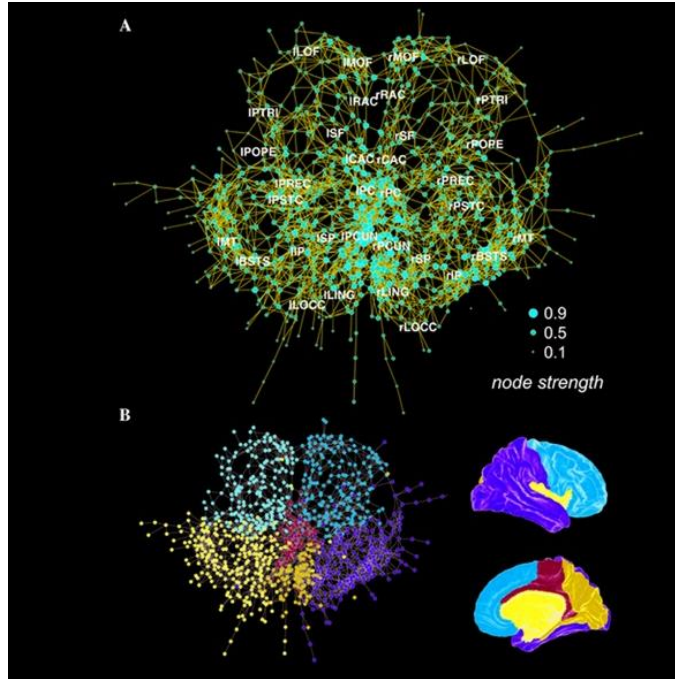


Figure 1. Brain networks (Sporns, 2011)

Its vitality in space is defined by the codifiability of existing knowledge, which is articulated in the body's connectivity network system. The body's experience of space provides knowledge. Knowledge is transferred to space by the body and exists in the body as an entity in the same way that knowledge exists in space. What is referred to as the body in this context is embodiment. Embodiment is what acquires experience through space, transfers that experience to space, and then acquires experience again with the transferred knowledge. Since information is coded in this network, the network structure of space is where embodiment obtains experience. Each coded knowledge is articulated into layers with patterns and overlaps with a new layer. Each new layer is in a mutual relationship with the previous layers of the space. In this way, it increases the dynamism of the space by articulating with the networks that form its features and form the connected integrity of the whole. Thanks to the spatial body with increased dynamism, it re-creates its existence because the increase in dynamism contributes to the emergence of the vital formation of space. The spatial body that constitutes vitality is shaped through the experience in this network.

In their book "The Tree of Knowledge," Maturana, H., a neuroscientist, biologist, cyberneticist, and philosopher, and his mentor Varela, F., state that "knowing is the act of the knower; its roots are in the living being, its organization" (Maturana & Varela, 2020). As a result, through experience and its networked structure, embodied space codes knowledge. With the change in space, the process of knowing creates an identity in the connectivity network of space. In this way, the embodied space chooses between codable knowledge and non-codable knowledge. The space that one can choose creates its mind. Neuroscience defines the mind as a simulation of neuronal network transmission in the brain. The mind is an autopoietic model. As a result, it is defined as a life-defining model. Every connectivity, every self-similarity, can turn into the coding of existence and then into another in the network of existence known as life. Through sensation and sensory coding, the production of mind in the vitality of space and body is possible. With this coding, space exists as a living system with a cyclical vitality.

### 3.2. Autopoiesis

Humberto Maturana and Francisco Varela developed the autopoiesis approach in the 1980s. It is a combination of Greek terms (autos: self, poiesis: organization, production) that means self-organization (Maturana & Varela, (1980). The concept of autopoiesis is based on the idea of a system organization that produces its components. Biologists use the term autopoiesis to describe the sphere of existence of a living organism that oscillates between structure and knowledge exchange. The concept of autopoiesis is also based on the idea that living systems are based on the mechanism of self-reproduction (Maturana & Varela, 2020). One of the most important definitions of autopoiesis is that all living systems and beings are cognitive systems because cognition is always alive (Figure 2). Cognition is a system that can be added to, articulated, and reproduced, and every field and science where cognition is present always points to the existence of the autopoiesis network (Maturana & Varela, 2020).

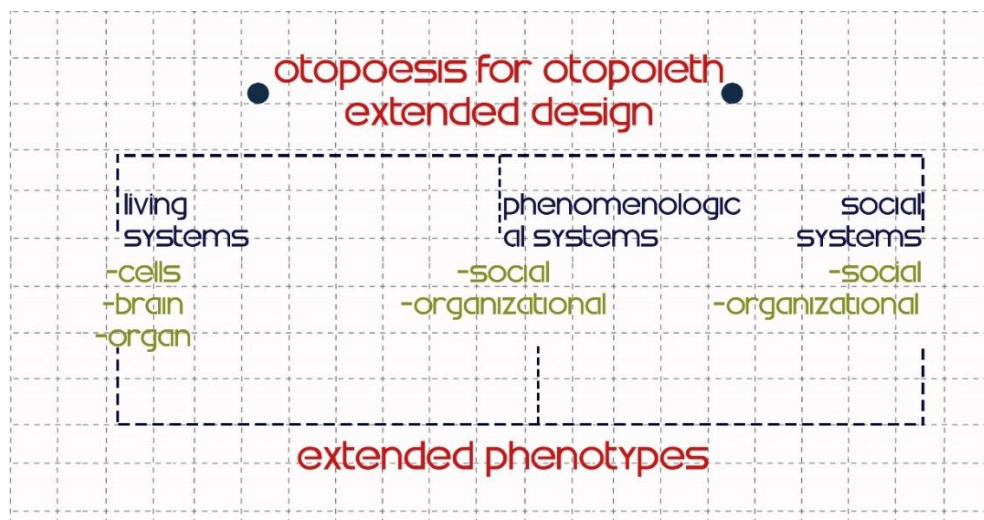


Figure 2. Autopoiesis systems

The idea of autopoiesis is the theory of Maturana and Varela's contemporary vitality systems (Maturana & Varela, 2020). Within the framework of this theory, vitality maintains its continuity only to live and reproduce itself. Every system that shows the characteristics of an autopoietic system constantly renews and recreates itself. An autopoietic system is a living system. Living systems also exist as both open and closed systems. Its characteristic as an open system is that it is a system that can receive and change data from all its relational contexts, while its characteristic as a closed system is that it can make its products with the knowledge it acquires from itself. Autopoietic systems are in a state of exchange of matter, energy, and knowledge outside their boundaries. This exchange maintains the integrity of the working principle of the system by preserving it within the matter, energy, and knowledge system. The cognitive knowledge of the living being in the system allows for the preservation of integrity. Maturana uses the expression "knowing is doing" to describe the concept of autopoiesis. Maturana's phrase "knowing is doing" implies that knowledge is linked to action and that cognitive processes can be thought of alongside acts, behaviors, and functions. That is, knowing something implies acting as a being capable of doing and interacting with it. Acquiring knowledge is not only a passive process in this context, but it is also an active process that occurs in conjunction with action. Maturana's approach demonstrates that knowledge is not solely a human concept but is also related to how living beings and living systems perceive and comprehend. According to Maturana, the way living beings perceive, understand, and interact with the world has evolved through evolutionary processes, with biological factors also playing a role. According to this perspective, cognition in general refers to an effective doing that allows a living being to survive in a defined environment as its world unfolds before it (Maturana & Varela, 2020).

Life transforms by exhibiting autopoietic behavior in the cognitive process. Transformation by autopoiesis theory is based on the organization that ensures vitality. Maturana also approached the

concept of organization from a biological perspective. According to him, organization is a distinctive feature of living things, and the structure and behavior of living things depend on these organizations. Each component of the organism collaborates with the others to form the whole organism. This harmonious work is the basis of the organism's organization. Autopoiesis includes a state of self-production and contributes to each component's ability to produce and transform other network structure components belonging to the function along with each component. The network in the autopoietic system is constantly self-generating as a result of this situation. Cognitive living systems are those in which the components' production is continuous. This cognitiveness always indicates the presence of the cognition autopoiesis network (Capra, 2003).

The nervous system, the largest cognitive system in life, contains billions of cells, all integrated as components of the organism. Cells in the nervous system are able to maintain their boundaries and at the same time, through their interconnections, maintain their cell associations as second-order self-existing systems. As a result, the nervous system is the most prominent example of self-generation. Neurons emerge in the nervous system as part of a networked system. As a mechanism that maintains the organism's structural changes, the nervous system contributes to cell communication reactions. The nervous system is a network of active components in the organization of life, where each change in reactive communications causes another to occur. It generates its own nature of autopoietic systems that create themselves through their organization and produce the structural elements of the system (Petrušonis, 2021). Space has an organization with networks of connective integrity. The space realizes its self-existence in the network of connectivity and the fact that everything that happens is under a state of conservation is specific to cell division in living things, but the space realizes its self-existence through the transfer of knowledge from the organismic body. In other words, space brings its vitalization into existence. In order for a space to be autopoietic, its network structure must be organized, each connectivity network must be able to produce itself, and structural interconnection between environments must be established (Dollens, 2015). Through autopoiesis, structurally coupled systems act as knowledge processing systems, producing new knowledge (pattern), i.e., intelligence. Through self-creation, autopoiesis creates a new coding system. With the knowledge entering the space, it creates a different paradigm of existence. This paradigm is distinct from the information codes that ensure the space's integrity. Autopoiesis results in the formation of new connective integrity in space and the transformation of space.

Diversity provides a type of adaptation for the continuation of self-existing systems. Space has a dynamic relationship context of adaptation with the environment as a result of its autopoietic behaviors in the structure of connective integrity. As a result, space ensures the continuation of its own existence. Using the collective state of many knowledge inputs, the space generates a code for its own production. It is a type of collective consciousness formation that occurs in the conscious mind during its production. The collectivity of its codes produces space. The space is now continuing to form on its own. Nature's own production system is based on the collectivity of space. The ability to exist and produce in nature is due to the fact that it behaves as a Voronoi system due to cellularity. In nature, Voronoi systems are structures that divide an area (e.g., plane or space) based on multiple points (e.g., atoms, molecules, or cells). The Voronoi system represents a zoning structure in which each point is surrounded by other points that are closest to it. This region is located in the center of a region that is closer to all points (Asghar, Jalil & Zaman 2020). This system can be found in many natural settings. Nature also creates production networks, such as self-similarity in the Voronoi system, which is required for its survival. Self-similarity is a property that describes how a part of a structure at one scale is like other parts of the same structure at different scales (Asghar, Jalil, & Zaman 2020). The relationship between Voronoi systems and autopoietic systems is based on their roles in organism spatial organization. Voronoi systems assist the organism in carrying out its functions by ensuring that cells and tissues are arranged in a specific order. On the other hand, autopoietic systems allow the organism to automatically create and maintain a certain order due to its unique structure. These two systems play a role in spatial organization formation. Since both systems contain knowledge-based and vitalizing formations, these systems are utilized in the production of space itself.

### **3.3. Embodiment**

The philosophy of the French philosopher Maurice Merleau-Ponty holds an important place among the theories of embodiment with its phenomenological approach to the notion of the body in an epistemological and ontological context (Merleau-Ponty, 2006). While challenging the sensation-centered approach of traditional epistemology based on the subject-object distinction, Merleau-Ponty's philosophy also challenges the ontological conceptualization based on the mind-body distinction and offers a body-centered approach to the human relationship with the world and thinking processes (Aydın, 2020). The embodiment of space makes sense of its existence through a networked relationship. In sensory research, it is considered as the knowledge of the sensation brought about by embodiment. The phenomenological understanding of the body contradicts the understanding of representation here, claiming that what is assumed to be represented is a product that emerges as a result of the body's interaction with the world, that is, as a result of the body's alignment with its orientation (Uslu, 2016). Knowing, memory, perception, learning, and behavior, for the phenomenological approach, do not correspond to a fixed and determined subject-object relation, but to a relation of embodiment. This depicts a field of experience in which the body is moving, changing, and repeating itself. This field of experience is the foundation that ensures the subject's unity of consciousness and body, the state in which the subject exists as a result of its continuous embodied interaction with the past and present. On this ground, orientation includes the embodied subject's experience of possessing and knowing things as participation in things outside, as well as the experience of being present and aware of things outside with its body. In this sense, it can be said that experience has two faces or is two-sided. These two sides of experience are the expression or definition of orientation as an unmediated and interactive field of experience (Gallagher & Zahavi, 2008). In the study, embodiment through networks of orientational relations; the relationship with the things in the world is considered as a non-fixable, non-determinable, interactional relationship in the process. The relationship of indeterminateness, just like the subject-object, mind-body distinction, Deleuz's singularization by transcending the actual-virtual distinction, these opposites disappear and gain meaning beyond representation. Thinking in the theory of non-representation is fluid and a process rather than something fixed. Due to this fluidity, it can be said that rather than being a theory that explains issues or produces formulas, it is a style, a way of handling events (Uysal & Güngör, 2017). In the research, the embodiment is considered an organismic formation.

Any codifiable experience is linked to the mind because the mind contains dimension and layeredness. The mind's layeredness creates a context through the production of senses and the knowledge coded by experience. This context is a connective integrity relationship. In the transmissions of 100 billion neural networks, the brain, which has the largest network of connective integrity, establishes the context of sensation and mind (Kılıç, 2020). Neurons, the building blocks of neural networks, are also sensory data carriers. Action is contained in carried sensory data. Each action results in transmission. Each neuronal transmission generates thought and meaning. Experience is a meaningful relationship. Essentially, all senses interact. (Pallasma, 2014). Experience requires the interaction of the senses. Environmental experience, spatial qualities, and atmosphere have an important role in spatial experiences. (Şimşek, Balkan & Koca, 2022).

Maturana Varela defines experience as a phenomenon within cognitive processes that arise as a result of the cause-and-effect relationship between organisms and their environment. (Maturana & Varela, 2020). In the relationship between the organism and the environment, the organism takes characteristics of the environment and uses them in its cognitive processes. Cognitive processes shape the organism's experience, and these experiences are mirrored in the organism's mental world. The sensory coding of experiences shapes embodied space. The embodiment, which gains new experience in the shaped and changing space, returns this experience to the space. Space coding are becoming more diverse. This sensory coding process is also considered cyclical.

Sensory coding is a type of information coding. The content of sensory experience is directly related to what is referred to here as knowledge, the content of knowledge. When viewing knowledge as a complex process, the process in which it is located influences the sensory fields of knowledge in space.

Space, with its existence and connectivity in its layered structure, is also within the senses. The first stage of knowledge is the sensory stage or the stage of sensations and impressions. The sensation is dependent on action. Sensibility and action are not mutually exclusive concepts (Özgencil Yıldırım, 2017). The computational modeling of sensing, which has recently become a growing area of interest in robotics research, has also been a source of debate about how to design and model sensing. Thanks to the idea that a strong organizational behavior based on bodily regulation is 'useful' in both biological brains and robotic cognitive architectures (Damasio, 1994), the sensory parameter plays a major role in explaining the shaping of space through sensation. The transfer of sensory parameters will help us see space as a bio-digital formation.

The space saves the various experiences it has with embodiment. As a result, space generates its own episodic memory. The production of sensory code in space is enabled by episodic memory. By creating different experiences and different interactions with each sensory code produced the space becomes a dynamic productive place by creating its own mind. The space, as a dynamic system, uses the knowledge generated by sensory coding realized in its reticulated structure to maintain the continuity of its internal relation. In its internal relationship, space creates new connectivity. By capturing the sensory parameter inputs included in the space as connectivity increases, it creates the mind of the space by providing more than one consciousness formation in the space. One of the goals of sensory coding is the formation of consciousness, which occurs in the space's own connectivity network, transforming the space into a creative active system. A space that is creatively active and dynamic becomes self-existent. This situation has an impact on the space's productivity.

Son-O-House, one of Lars Spuybroek's projects with NOX Architecture, is a house inhabited by sounds, a memory of sounds, and an experience of sounds (Figure 3). Son-O-House, a structure in which Lars Spuybroek, composer Edwin Van der Heide, and visitors collaborate to create a "memory landscape" of sounds in and near space, is not a "real" house, but rather a structure that refers to visitors' bodily movements and a sound work that constantly generates new sound patterns (Bullivant, 2005). The Son-O-House project has a generative and reactive sound environment. The project is activated by sensors that detect the actual movements of visitors and continuously generate new sound patterns. The goal is to have a constantly evolving environment that forces visitors to come back, to perceive the new musical situation, and then to relate and interact with it again.

The 3,300 square meter structure has 23 sensors placed at strategic points to function as an interactive sound work (Bullivant, 2005). The music emitted into the environment indirectly affects the people present. People involved in the project not only hear the sound but also contribute to its creation. Spuybroek describes the structure as "an instrument, score, and studio all at once." The sound system was composed and programmed by sound artist Edwin Van der Heide and is based on the movements of the interference of closely related frequencies. The sound project is continuous, with infinite variations caused by bodily intervention in space. A visitor said that as he rode his bike up to the house, he could hear the installation buzzing like birds in the background. When he entered the space, he noticed that the sounds had changed due to his presence and movements. NOX recorded the sounds made by visitors as they entered or walked around the space, using sensors that indirectly affected the emitted sounds (Bullivant, 2005). As a result of the interaction between the environment and the human body, space has changed by transferring it to space. The structure reflects the changing sounds of each visitor, forming a continuous composition cycle. The network structure of space (sound) has been able to reproduce itself by drawing interaction from the human body and the environment towards its own structure. Space forms the network structure with sounds. Each visitor has an orientation for the sound in the space. They transfer sound from the environment to the space when they enter it. The network of connective totality between space and the human body was completed when they realized the sound emanating from space was one of their own movements. It is a cycle. Now space produces itself.

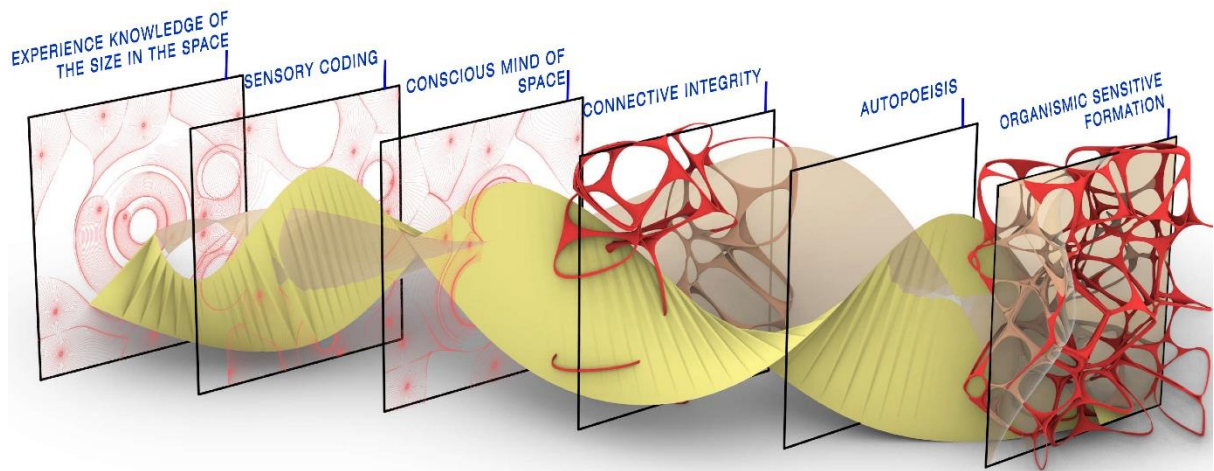




**Figure 3.** Sound sensors are placed in the space (Heide, 2021)

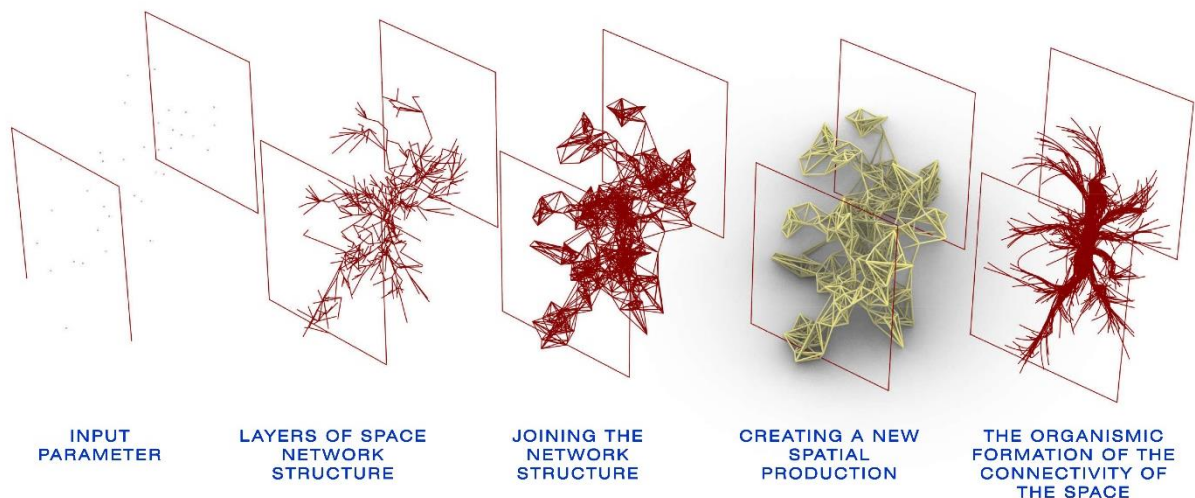
As seen in Lary Spuybroek's Son-O-House project, space is sensed. The sensed space produces different and diverse new productions. Through its experience in space and its relationship with time, the body enables the emergence of a new phenomenon. This is because experience is the emergence of meaning from the exchange of knowledge between body, space, and time. The embodiment of space allows the experience to be used as data. Each data triggers a new experience, and each new experience triggers a new generation of data. Every data that enters space produces infinite variations. Space creates its own internal dynamism with the coding of these data (senses). The space with increased internal dynamism becomes self-productive in order to be able to code more.

Thanks to the sensory coding of the space, it transforms and takes shape with the space and its body, and then transforms each received code. The knowledge that enters the space through embodiment contains senses, and the space performs sensory coding using this knowledge. This knowledge coded in space also creates energy transformation in the networked relational integrity of space. This contributes to the dynamism of the connective integrity of the space. It enables an increase in diversity in the mind in dynamic space connectivity. The increase in mind diversity that occurs in space enables the formation of the dimension of cohesion, ensuring that each knowledge input in the mind remains permanent. The presence of permanent knowledge distinguishes subsequent knowledge inputs. Different sensations can occur as a result of the transfer of different knowledge into this space. In other words, embodiment affects the continuity of the coherence dimension in the continuity of the sensation process through this task. The embodiment of space allows the reticulated structures to create their own mind through the dynamism of its multiple dimensions. While this event serves as the foundation for the space's mind formation, the space, as a living system, continues its cycle in its own production (Figure 4).



**Figure 4.** The space's own production continuity cycle process

This cyclical process is critical for the persistence and diversification of mind formation in space. Space must be embodied in order for this diversity to persist and produce itself because to harbor embodiment means to harbor the mind. The space that harbors the mind is dynamic and this dynamism can always be sustained with the continuity of mind formation. In this process, the space, whose dynamics increase, becomes a whole together with the codes produced because it is a set of codifications that exist intertwined in all life. The space that harbors a life with the presence of mind allows each code it creates to transform each other. Each transforming code produces new connectivity in the embodied space and sustains the continuity of the relation of connective integrity in space. The connective space brings about the formation and continuity of a patterned input. Patterned input is necessary for the space to produce. This is because many patterned inputs exchange knowledge with each other in order for the space to produce itself. Each input produces a network on its own. The network produced is diversified by joining the network structure already present in the space. The diversified network structure designs the mind of space through the integration of various dynamic components. The designed integration combines the space's input knowledge in a flow with the space's networked structure between the layers. In this way, it creates the connectivity of new spatial production by articulating the networked structure of space (Figure 5).



**Figure 5.** Flow parameters in space

Structural transformation occurs in space, resulting in new connectivity. Space is in a structural transformation and this transformation is also a dynamic movement. This is due to the fact that every

structural transformation of space enables it to diversify through new areas of experience and the impact-response it will have on the organismic formation of its relationship with its environment. The mechanical, organismic behavior of the parameters of the vital network transforms the systems of space, environment, and body. With this behavior observed in the space, it can self-exist.

#### 4. Finding and Discussion

##### 4.1. The Experiment of Biodigital Formation of Space

The autopoietic system is based on knowledge theory and the codifiability of knowledge. The theory of knowledge is a theory that is interested in scientific abstractions in order to understand the mysteries of the universe, make sense of it, reveal the true causes of social development, or formulate scientific theories. Abstractions contain practical knowledge. This knowledge includes theoretical thinking and model building. The cybernetic organismic sensory formation of space is aimed at the emergence of the cybernetic organismic sensory formation of space in the experiment conducted to explain the data obtained from the theoretical framework, and the rules of vitality formation predict geometric coding and the discovery of possible spatial patterns. Cybernetics is currently defined as "the branch of science that studies the control and management of all complex systems, both living and non-living" (Jenkinson, 2021). Norbert Wiener, the most prominent representative of the concept of cybernetics and a mathematician who developed theorems, defined cybernetics as a complex, adaptive, autonomous, and circular form of organization and knowledge transfer that allows all its parts to be combined as a complex system in any living or non-living system (Krippendorff, 2007). Humberto Maturana demonstrated the science of cybernetics using organisms. According to Maturana, the functioning of cybernetic systems is ensured by feedback loops. While explaining cybernetic systems, Maturana also emphasizes the difference between first-order cybernetic systems and second-order cybernetic systems (Figure 6).

cybernetic systems according to maturana / varela	
1st degree cybernetics systems	2nd degree cybernetics systems
provides balance	self-management and change
predetermined information	information that can be produced by itself
external controlled routing	information can be processed and analysis.
a system that cannot renew itself	can response to warnings from the outside.
	self control
	can be changed by own.

**Figure 6.** Cybernetic system features according to Maturana & Varela (2020)

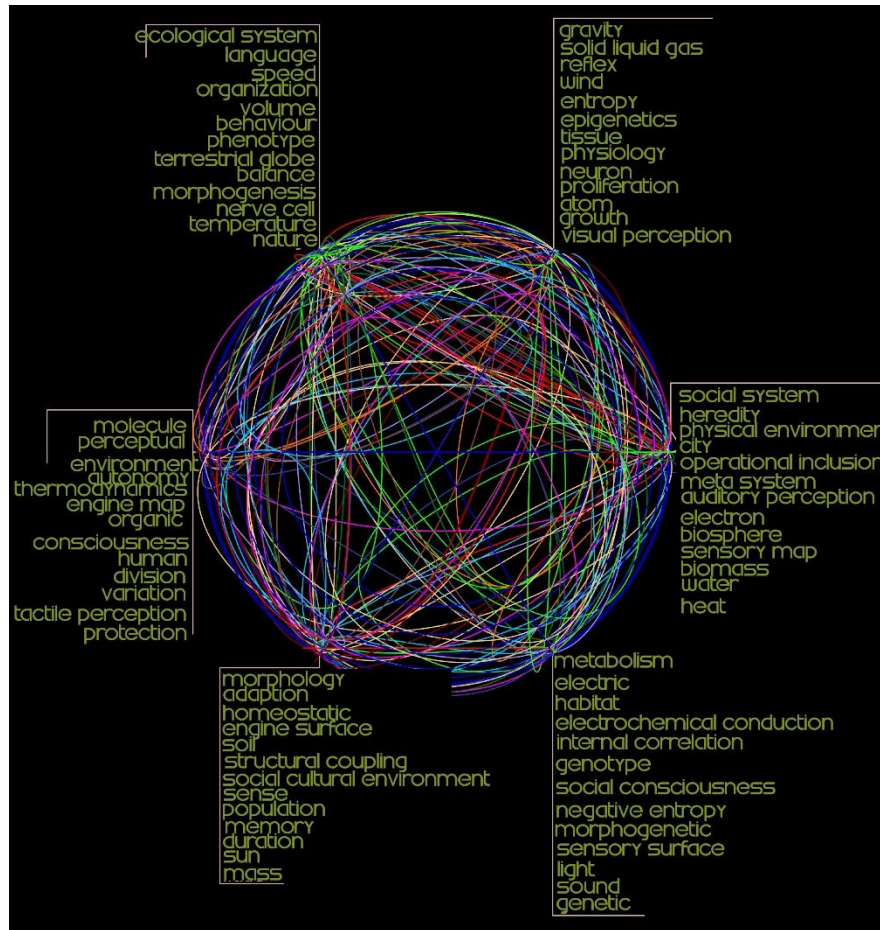
First-order cybernetic systems are those that can control and correct themselves using feedback. Second-order cybernetic systems are systems that are aware of their own existence and can use that awareness to change themselves. These systems can produce and reconstruct themselves. According to Maturana, another characteristic of second-order cybernetic systems is that they can know about themselves and use this knowledge to change themselves. Therefore, living organisms and living systems are examples of second-order cybernetic systems (Maturana & Varela, 2020). Living organisms can adapt faster and develop more complex behavioral patterns when they are in an environment where they can change their own structure and control their own behavior. In the experiment, space formation is designed according to the properties of a second-order cybernetic system.

Space is always in a dynamic production process with its second-order cybernetic properties. Space defines the transition to cyberspace in the age of networks through its dynamic, collective, and self-organization by structuring its own integrity. The transition of space to cyberspace is the transition of space from static to dynamic, from passive to active, from fixed to fluid and variable surfaces. The space thus creates spaces for a multi-sensory experience. Turning into cybernetic spaces of experience, space is an interactive and constructive state (Novak, 1995). Experience is redirected and new meanings emerge as a result of its transformation through embodied meaning (Merleau-Ponty, 2006).

The knowledge of space connectivity network functions as a computing system that can learn embodied experiences as input and draw conclusions from these experiences. In space, this knowledge processing system is formed in layered networks. The flow of knowledge moves between layers along a network of connectivity and integrity. This input of knowledge between layers is transformed by space into a new field of experience. These experience spaces are cyberspace experience spaces.

There is a necessary harmony in the embodiment of space. Embodiment shows an enveloping environment. There is a flow of knowledge in the embodiment. This knowledge parameter is the activation of space. Each newly uploaded knowledge creates a new spatiality. Spatiality is the result of a cognitive process. This cognitivism is treated in the experiment as a revelation of the dynamic relationship between the parameters of space within the digital context while adhering to the rules of organismic formation. For this purpose, 3D modeling programs Rhinoceros and Grasshopper with digital interfaces are used.

The system created in the experiment is a universe and the emergence of embodied space will be considered as the evolution that takes place in this universe. In this process, evolution develops an exchange of knowledge between layers. In the context of this exchange, the new model of space used today is viewed from a dynamic emergence perspective rather than a static structure. This perspective sees the patterned diversity that emerges in a non-homogeneous construct over time as a creative act (Arıdağ, 2018) because life changes, transforms, converts, and produces due to its nature. This is a cyclical process. All production takes place within the designed time universe. The universe is created in a circular coordinate system. Each intersecting point in the coordinate system generates points that allow space to be productive. These points are then matched with the data that will be used to calculate productivity. The knowledge matched with the dots is transferred to the embodiment of space as a layer. Space exists because of the relationship it creates between all of these knowledge systems. This knowledge is virtual knowledge. The knowledge parameters, which are considered a subheading of the virtual knowledge, are matched between the points in the coordinate system where they are located (Figure 7). More than one parameter can have multiple matches. These matches create a chaotic situation in space. Every chaotic system somewhere demands equilibrium according to a property of living systems.



**Figure 7.** Chaotic situation caused by experimental matching

The experiment initially shows a chaotic situation as a result of the matching between the groupings of all layers. This chaotic state is the result of the intersection of certain parameters of vitality. Intersection points act as synapses in the nervous system. They are involved in the system as nodes and transmission points. In the experiment, these points act as an electrochemical transmission and the beginning of the organization between the brain and organs, just as synapses do in the brain. When conduction occurs, a chaotic situation in space occurs (Figure 8). The experiment chooses among the parameters that will generate spatial productivity in order to bring the chaotic universe into equilibrium. Chosen pairs; specific heat capacity, density, solid, liquid, gas, mass, atom, equilibrium, negative entropy, heat, temperature, thermodynamics, homeostatic, autonomy, physiological, sense, memory, communication, metabolism, growth, reproduction, organization, neuron, electro-chemical, genetics, epigenetics, morphogenetics, motor map, sensory map, heredity, genotype, phenotype, motor surface, sensory surface, internal correlation, structural correlation, procedural inclusion, variation, nerve cell, entropy, tactile sensing, auditory sensing, and visual sensing, produce parameterized knowledge, i.e. the chaotic state. These selections show the context between the parameters of the self-organization of space and the parameters that will change the embodiment of space. Space produces itself through the knowledge that is in itself.

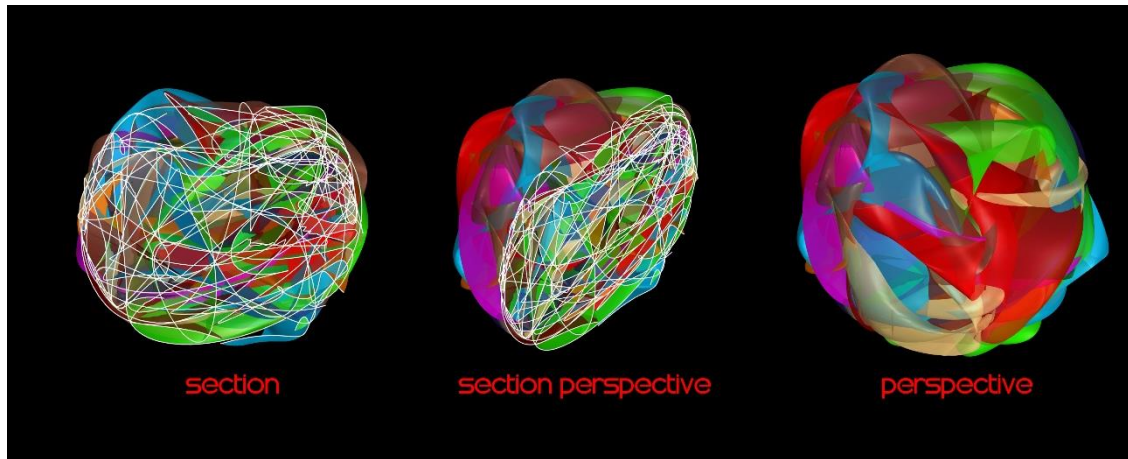


Figure 8. Initial situation before selection in the experiment

In order for the chaotic space to reach equilibrium, selection will be made according to Maturana's concepts of vitality. Maturana, too, defines vitality as systems that are constantly renewing and reconfiguring themselves, a process he refers to as "autopoiesis." (Maturana & Varela, 2020). This process allows living things to preserve their unique structures and maintain their continuity. He explains that every self-renewing system carries knowledge, and that knowledge consists of the act of knowing. Every knowing creates an action, a universe, a life, a vitality.

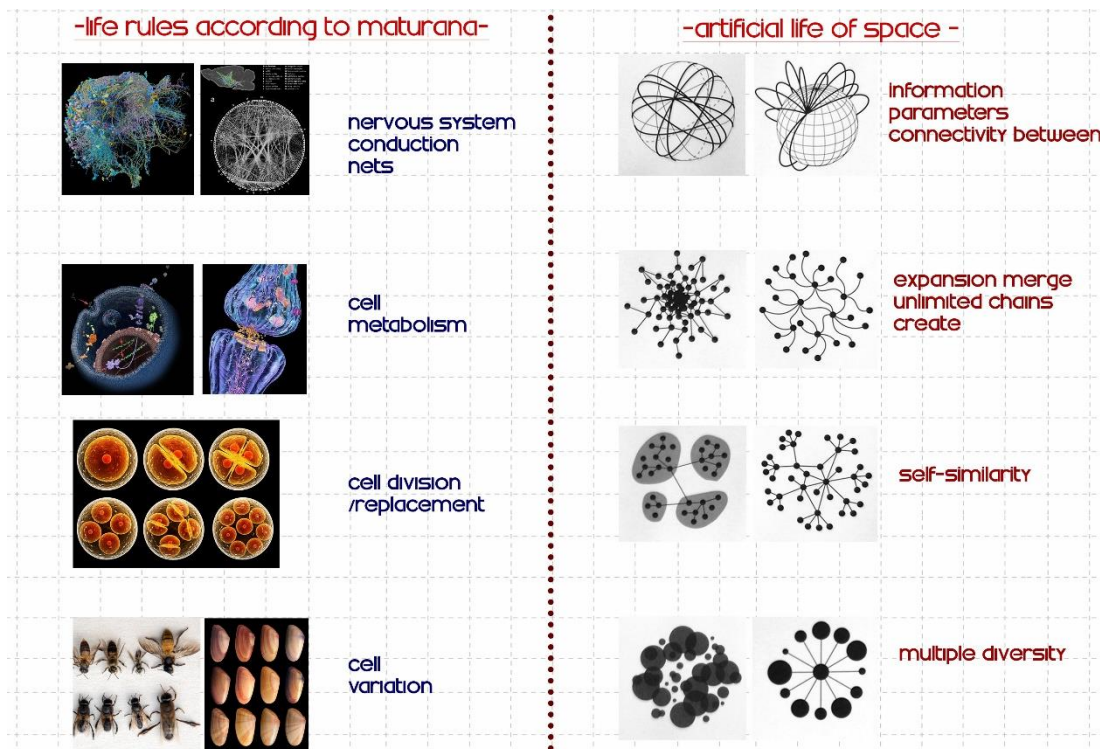


Figure 9. Connection diagram between experiment and cell organization

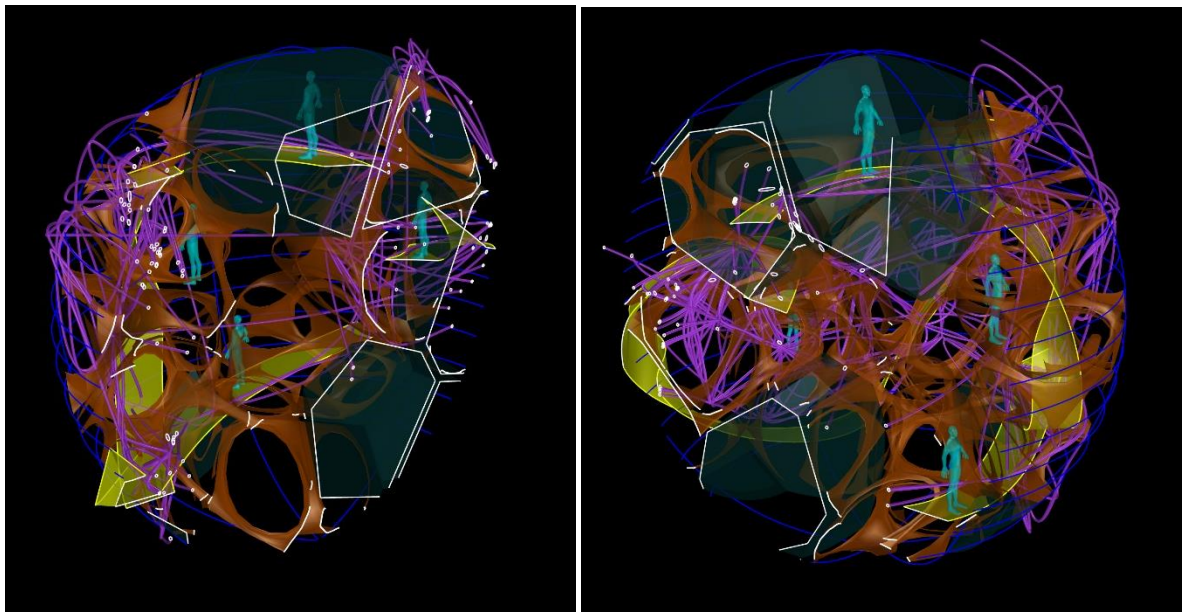
According to Maturana's theories of vitality, selection takes place between pairs (Figure 9). These selections consist of points in a coordinate system. The points joined in the Rhino program create the artificial life of space. In order to make this combination understandable for the artificial life and production of space, networked knowledge connectivity is created using the "physeralm" plug-in in Grasshopper. Thanks to this plug-in, the simulation of the production network that will be formed in the embodied space can be seen (Figure 10).



modulation models. In the context of this research, modulation is based on the search for a self-similar Voronoi structure. From the moment the movement of the human body begins to be considered in it, it continues its flow by becoming scaled with new parameters within the embodied space.

## **5. Conclusion and Suggestions**

In general, the theory of evolution has taught us to recognize, measure, and simulate the complex order model that emerges from self-organization and evolutionary processes. According to Schumacher (2015), freedom was obtained by giving up order in the 20<sup>th</sup> century. But the parametric approach helps develop the idea of order, without giving up freedom in the 21<sup>st</sup> century. The balance between freedom and order is obtained with the operative matrix. This operative matrix works both by making the dynamic parameters in nature visible by simulation and by running this visibility as the codes of the design process. The operative matrix controls the movement in this dynamic system, allowing new design decisions. Therefore, the design process turns from an analytical and logical structure to an evolutionary and intuitive structure with layers. This enables flexible adaptive variability in the spatial design (Arıdağ 2021).



**Figure 12.** Artificial life in space

James George Frazer defined the concept of evolutionary design as "the acquisition of beneficial properties of an organism as a result of natural selection". According to this approach, certain characteristics of an organism are acquired through the process of natural selection and passed on to subsequent generations. Considering the existence of natural selection through evolutionary design theory, evolutionary design is a creative process in terms of form production, and architectural concepts can be determined as a set of generative rules encoded as codes participating in the evolution process (Frazer, 1995). By defining architecture as an artificial lifestyle, evolutionary architecture describes processes that can develop and evolve in response to the user and the environment. Evolutionary architecture aims to create common behavior and metabolic balance in the natural environment. It directly participates in the design process of nature and behaves similarly to an organism. According to Ho (2001), an organism creates its own space-time through its actions. Therefore, a space that controls its own space-time can evolutionarily produce the design process and itself. According to Ho (2001), the theory of evolution can be a source of inspiration for innovation in architectural design. It can be thought that natural selection and adaptation mechanisms of biological organisms in the evolution process can also be applied in architectural design. It conveys the evolutionary process of space, which creates its own information network in the age of networks and visibility in its own artificial life.



It conveys the evolutionary process of space, which creates its own information network in the age of networks, and its visibility in its own artificial life. In this situation, in the simulation where the formation of the artificial life of the space is observed, it is observed that the information that creates its own network structure creates its own spatiality. The interaction of the data obtained from the information parameters in the changing transforming fields in the network structure occurs in the context of evolutionary randomness. Space acquires new experiences with dynamic, lively, productive incarnation, produces new patterns, and arrives as an autopoietic system. It changes the space in the parameters that enable it to act as an autopoietic system that creates the space and enables it to evolve (Figure 12). With the evolution of space, space rebuilds its own existence. Space offers different experiences to the body that acquires and produces experience. This experience changes and transforms every moment. It transforms in its own dynamism by transferring the transforming experience to the space. The productive, networked, and flowing space is adaptable to all conditions. In this way, it continues its evolution. With the data obtained, the perception of the concept of vitality through space and the experiences that will be gained in space has an important place in the explanation of cognitive coding systems. When the theory of space autopoiesis is considered, a dynamic, networked productive space understanding is formed. These concepts reveal that the codes of life, life, and evolution are whole;

- Otopoeisis makes its own dynamic production of space. Because space is a dynamic process that establishes, creates, transforms, and protects its own organization.
- Incarnation is the product of an embodied mind; the body's senses and experiences shape and transform space.
- Atmosphere, reveals the sense in the space. It provides the formation of sensory coding data with the experience gained in the spatial information network.
- Cybernetics, exists in the process that establishes the exchange of the information input of the artificial life of the space between the space itself and the people living in the space, within the framework of mutual observation, and enables the space to return from a chaotic state to a balance.
- Time, on the other hand, exists as a universe that enables the evolution of space to take place by creating meaning in its own organization. Time is the universe of space as cyclical time.

The discovery of the rules of life and reproduction, the space formed by coding information through digital experiments, and the idea that space has an organic structure, unlike the Cartesian dualism understanding, will enable the evolution of future space understanding. Within this information, Maturana's theory of autopoiesis, Ponty's theoretical approach to embodiment, and Deleuze's theory of singularities offer a perspective that contributes to the understanding of biodigital space formation from a neuroscientific perspective. In particular, he emphasizes that autopoietic embodiment actively interacts with all kinds of influences and that these interactions cause the spatial body to constantly reconstruct itself. According to this perspective, the formation of biodigital space is also based on the interaction of the body and embodiment (Figure 1). When we read this through the generative structure of space, communication between the environment and the embodied space is established. The differentiated experience is reconstructed by the embodied space. In other words, space and body cannot be considered separately from each other. Productive space is adaptable in all circumstances. In this way, it continues its evolution. The data obtained, as well as how the concept of vitalization is perceived in space and the experiences to be gained in space, play an important role in explaining cognitive coding systems. Readings on autopoiesis theory and neuroscience theorems, as well as the ability to control the dynamic and chaotic increase of knowledge, result in a networked productive, more responsive understanding of space.

The idea that space is not only a physical dimension but also a part of all systems related to vitality and life, will increase its sensitivity and contribute to the research of future space understandings such as metaphysical space, meta memory spaces, biodigital space, and generative space. If planning, designing, or understanding pluralistic and ecological environments in a societal context is truly

desirable, the spatial design strategy put forward in this research could be a way out in an effort to establish a balance between humans and nature.

You can watch the formation video of the simulation from the link below.

<https://youtu.be/YT6rySMsIBk>



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