Symmetry as repetition

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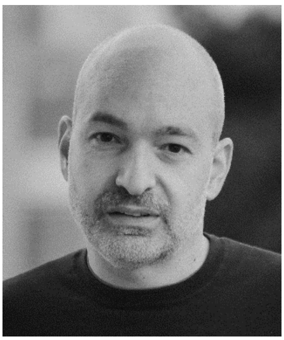

Abstract

Symmetry is an old ordering principle that has inspired and explained the developments in many different scientific and artistic fields, like physics, biology, or architecture. In a moment when contemporary design experiences an increasing geometric freedom, why does a traditional subject like symmetry could be of interest for designers? It seems reasonable to question the value of symmetry in contemporary, computationally driven design.

Klaus Mainzer resumes the current tendencies as a move from symmetry to complexity, where the platonic union of truth and beauty is broken and transformed into diversity and heterogeneity. Indeed, the digital avant-garde embraced the power of digital computation with great enthusiasm, which resulted in new emergent generative or evolutionary systems of forms. For example, we can conceive of organic forms as something which is produced by the interaction of numerous forces which are balanced against one another in a near-equilibrium that has the character not of a precisely definable pattern but rather of a slightly fluid one, a rhythm. In that context, symmetry might initially appear irrelevant or even as a counter principle.

Complexity is mid-point between order and disorder. When complexity is symmetric, two core determinants of visual aesthetics come into play. Natural structure suggests the necessity for

differentiation, followed by collective organization marked by a high degree of multiple symmetries. Architectural evidence reveals the principle of broken symmetry as a key feature of buildings that mimic living structure. The present paper offers an attempt towards such an approach of exploring balance between searching and breaking the codes of harmony, breaking symmetry, then using it again.

As the understanding of aesthetics has been recently shifted from the traditional study of beauty towards the redistribution of the sensible, an idea developed extensively by Jacques Rancière, we can approach symmetry through a similarly different lens: Not as a property of sameness but rather as repetition that operates in terms of difference. The mirrored doubling of symmetrical processes can be seen as process that produces rhythm, modulation and ultimately difference.

The art of petrified silence

Structure speaks through the silence of perceptual phenomena. [1] Deleuze and Guattari describe three disciplines of thinking: science, art and philosophy. [2] Science fixes the world into observable 'states of affairs'. Philosophy creates concepts; these concepts do not label or represent the world so much as produce a new way of thinking and responding to problems. Art creates affects and percepts. Our senses are the transducers from the physical world to the realm of the mind. The percept is the resulting mental re-creation of the sensory information. Images of one sensory realm feed further imagery in another modality. In Okakura's description the present and the absent, the near and the distant, the sensed and the imagined fuse together. [1] According to Brentano, physical phenomena engage our "outer perception", while mental phenomena involve our "inner perception". The challenge for architecture is to stimulate both inner and outer perception. In memorable experiences of architecture, space, matter and time fuse into one singular dimension, into the basic substance of being, that penetrates our consciousness. [1]

"*Art does not exist in itself; it is an outcome of a complex set of relationships between what one is allowed to say, to perceive, and to understand*", Jacques Rancière.

Since the late 1990s, Rancière has put forth one of the most novel and powerful accounts of aesthetics. Instead of taking art to be a historical constant and attempting to unveil its fundamental essence, he maintains that there is no ''art in general'' but only historically constituted ''regimes'' that establish a given distribution of the sensible and determine the framework of possibility for artistic production and theoretical reflection on art [3]. The French philosopher relates aesthetics to what he calls the "sensible," a noun that evokes perception and the senses (aisthētikos) rather than reason or good judgment. Aesthetics, is understood as a specific construction, distribution and perception of the sensible [4] in the sense that it redefines the very constituency of the sensorium. For Rancière, "*both industrial production and artistic creation are committed to doing something on top of what they do—to creating not only* *objects but a sensorium, a new partition of the perceptible*".[4]

Sensory perception is a realm structured by practices of repetition, that structure, rhythmize, and connect objects, events, and actions. The sensory perception of a certain materiality is turned into the starting point and goal of artistic practices. Art apportions a certain space and a certain time, and the objects with which it populates this space, and the rhythms into which it divides this time, determine a specific form of experience that is consistent or breaks with other forms of experience. [5] Rancière's work begins with the premise that our world is composed of lines in constant movement, alignment and realignment, these "dividing lines" that divide and connect aesthetic formations. There can be sought that possibility of "change through repetition" as rooted in the transformability of any distribution of the sensible. [5]

9 points on symmetry, repetition and difference

Symmetry has been a property that the 'traditional' understanding of aesthetics have been dealing with. However, when symmetry is understood through the concepts of repetition and difference Rancière's aesthetics as the redestribution of the sensible might come into play. In other words, when the act of generating symmerty is understood as an act of repetition that is able to generate difference then our understanding of the perception of the produced space is shifted. The example preseneted at the end of the paper, reveals exactly this emergence of difference through multi-layered form forming acts of symmetrical repetitions. Below, 9 points on the concepts of symmetry, repetition and difference set the general theoretical framework.

Point 1: Microgenesis of regularity

Most natural laws and occurrences, such as the coming and going of waves, the change of day and night, the changing of seasons, tides, breathing, heartbeat, pendulum movements, etc., are different manifestations of periodicity in time. The repetition of occurrences or states in identical time intervals is called rhythm (Ghyka 1977, p. 6; Alyakrinski and Stepanova, 1985).[6] Practices of repetitive structure, rhythmize, and connect objects. It is the object of repetition that deceives because it repeats but is never redundant. It remains somewhere between uniqueness and duplication, uncertain of either but certain of itself.[7] Repetition is a process that underlies all identities. It is that double identity of the "new" and the "repeated" that gives the letters for a new language to be formed. It is through the unique language of repetition that structure's poetry and lyricism are exposed.

Fig.1

Point 2: Difference within sameness

Derrida argues: *The verb "to differ" [différer] seems to differ from itself. On the one hand, it indicates difference as distinction, inequality, or discernibility; on the other, it expresses the interposition of delay, the interval of a spacing and* *temporalizing that puts off until "later" what is presently denied, the possible that is presently impossible*. [8]

Pure difference cannot be represented affirmatively by any concept that reduces it to being merely an absence of sameness. Representation thus considers difference to be a contradiction of sameness. Just as repetition implies a relation between a "repeater" and a "repeated," difference implies a relation between a "differenciator" and a "differenciated.[2] Repetition as a creative tool produces not merely copies, but rather multiple originals with noticeable differences and similarities. It is that repetitious act and particularly the sameness of each unit that draw attention to their difference. Furthermore, ruptures affected by repetition offer the possibility of a redistribution and reapportioning, a transformative reconfiguration, proposing new connections, activating previously overlooked capacities. [5]

Difference is not merely dependent on its relationship between two things, but rather is itself emergent and processual. The cycle of repetition is an emergent act, allowing difference to relay both distinction and delay. The latter promises another difference, another original, to add to the collection. It is through repetition that difference is invited and maintained. That is how repetition allows differentiation to emerge [7], serving as an anchor from which difference emerges. This echoes Deleuze's concept of repetition: "*Difference is this state in which determination takes the form of unilateral distinction. We must therefore say that difference is made, or makes itself*." [9] In the end difference is entirely represented by the unique object of creation.

Point 3: Simplistic vs complex repetition

Simplistic repetition is one such minimalistic geometrical setting in which we find no algorithmic complexity, hence no visual and intellectual interest. Usually, we recognize such monotonously repeating forms as unnatural. [10] Indeed, in nature we almost never find simplistic repetition on the macroscopic level. On the contrary, living structures show so much variation in the repetition that monotony is entirely avoided. Inanimate physical structures also almost always have some variations that prevent the monotonous effect to emerge.

A "bare" (simple) repetition is a mechanical, stereotyped repetition of the same element, whereas a "clothed" (complex) repetition is a repetition that conceals its own variability, and it may thus conceal difference within itself. [9] Complex repetition may have various elements that multiply or reflect each other. Pure difference may be reflected by complex repetition because both difference and repetition may be independent of any relation of sameness, similarity, resemblance, or equivalence between events or meanings. Repetition might be static when considered through sameness, but it becomes dynamic as long as we see it through difference. The play of repetition between sameness and difference is also the play of repetition between simple and complex repetition, between covered and uncovered repetition, between masked and unmasked repetition, between horizontal and vertical repetition, and between static and dynamic repetition. Repetition therefore operates between all those dualities and gains its value through their juxtaposition. As shown in figure 2, a sphere is transformed into an intricate structure, using a play between simple and complex repetitions as a process. That double play can also be detected in the final result.

Fig.2: A play between simple and complex repetition, digital 3d study model, experiments stage II/ Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

Point 4: Organized complexity

The Latin term "structura naturalis" refers to the immense range of concrete, physical, and natural structures that surrounds us in daily life. However, when one thinks about these structures, or form abstractions, or uses language to describe them, one is generating a "structura mentis"- a mental structure. These structures can equally go on to produce structura naturalis, in the form of the structures of the world. [11] While structura mentis is a potentially infinite domain of creative expression, structura naturalis is however, a much more concrete structure, with more specific and predictable human effects and consequences. Planners and designers must be clear about the relation of the two, and the coherence or the discord between them. The first step to discovering the geometric qualities we are looking for is to examine natural environments. This brings us to the effect of Biophilia.

Human beings prefer ordered complexity and not randomness in their environment, a result of our perceptual system evolving to interpret natural forms. [10] Some insight into the effect comes from the notion of Biophilia, which asserts that our evolution formed our neurological system within environments defined by a very high measure of a specific type of coherent complexity. That is, our neurological system was created (evolved) to respond directly and exquisitely to complex, fractal, hierarchical geometric environments. Edward O. Wilson used the term to describe an innate connection between all living beings.

Many ways of achieving order in complexity exist, involving continuity, different types of symmetries, scaling, correlations, harmony, etc. Most environments exhibit compound symmetries, including reflectional, rotational, translational, scaling, and broken symmetries. Humans are adept at perceiving these symmetries and the order that they manifest. Simple in nature means extremely complex but highly coherent.

Fig.3: Delving into details, digital 3d s tudy models/ Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

Complex geometrical properties are emergent; they are not obvious in the initial code. [12] Through a generative schema increasing complexity during the design process leads to high resolution architectures, allowing access to a higher degree of complexity giving the chance to delve into details on closer inspection, accessing different resolution at different scales. The challenge however, is to simulate complex phenomena while keep them in the realm of control. Symmetry as a gener ative process looks like the ideal means of organization to form "controlled" emergent complexity and eliminate chaos and anarchy. In a moment where contemporary architectural discourse balances between doing everything the same and doi ng everything different, exploring symmetry through digital means might provide a powerful design strategy to negotiate the best of both tendencies. [13]

Point 5: Symmetry as process and product

The contemporary application of theories of symmetry to architecture and design is a surprisingly neglected area of research. To assist in rectifying the problem, a new agenda for research is needed. Design exploration of symmetry can attract a renewed interest based on two main ideas: On the one hand, symmetry-based design supports the generation of unique and apparent complex solutions out of simple geometric rules, in a bottom-up fashion. On the other hand, despite this intricacy, it assures modularity in the design components, which can bring benefits at the construction level [13]. Also symmetric transformations (isometric or non-isometric) are used as a generative engine to discover new design possibilities.

It is clear from the existing literature that symmetry is a central component of human perception and understanding, and one w ith its roots in the biological need to apprehend the structure and meaning of the world. Symmetries in the living have their roots in the morphogenetic processes of growth, including folding, rotating, replicating, and so on. One can see the essential relationship between process and product.

The pursuit of symmetry in human structures stretches back to antiquity, and even deep into prehistory. The word symmetry originates with the Greek sym (together) + metron (measure), and thus refers to a c orrespondence between different forms with similar measurements or shapes. [11] Some theorists have proposed that "information"—understood as symmetrically related structure—is the fundamental structure of the Universe. That is, the structures of the Universe transform and differentiate from one another but preserve some symmetric relationships in combination with various forms of "symmetry-breaking," or differentiation into other structures. [14] This broader perspective helps to set the context for the exploration of symmetry as a phenomenon of both process and product.

Point 6: Types of symmetry

In geometry, the “symmetrical” form in question is said to be invariant under a given transformation, which may include reflection, rotation, translation, scale changes, or other changes. [15] Compound symmetries, which combine other kinds of symmetry into more complex forms, are what is experienced most in natural and human environments. In that context combination of reflectional and translational symmetry is what is known as glide reflection. The three basic plane symmetries, plus their 14 possible combinations, form 17 symmetry groups in two dimensions. Humans crave highly complex forms of compound symmetries with deep coherent inter-linkages, or what one may call “deep symmetry”. Connectivity and integration are central factors in experiencing our environment. We react with alarm at structures that exhibit no scaling coherence but visual coherence at all scales is perceived as “beauty”.[16]

Fig.4: Compound symmetries, digital 3d study model, experiments stage I/ Final thesis. Fall 2019, post graduate program ‘Advanced Design’, School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

Another important process of symmetry formation and transformation is symmetry breaking. Broken symmetries are often seen compounded with other symmetries in the irregularities of our world. [11] Symmetry breaking stabilizes the hierarchy against collapse. A careless use of symmetries to generate larger-scale forms leads to informational collapse: when the information contained in the whole is no more than that contained in the repeating unit used to generate it. Then, the information of the whole collapses into that of the single unit. Complexity that is most psychologically satisfying exhibits information on every scale.

In conclusion, the research agenda of symmetry seems to be multidimensional as different parameters concerning the combinations and ultimate choreograph of symmetries comes into play and contribute to the product’s final coherence.

Point 7: Mirror symmetry and perceived objectness

To human observers, there are substantial perceptual differences between kinds of visual regularity. Most comparative studies are dedicated to contrasting the two most prominent cases, namely mirror symmetry and translational symmetry that are regularities that the human visual system uses to process and structure the information that enters through the retina. [17] As far as the idea of perceived objectness is concerned, these studies show for instance that mirror symmetry is more salient and more noise-resistant than translational symmetry. In fact, they seem to have opposite effects on the perceptual formation of objects. Mirror symmetry seems to integrate pattern halves into perceived wholes, while translational symmetry rather seems to signal the presence of two distinct objects. They also had participants discriminate between symmetric and repetitive patterns in which the pattern halves were either adjacent or separated by a fixed distance. They found that mirror symmetry is more salient than translational symmetry when there is no spatial separation between the pattern halves but the opposite is true when there is. Apparently, manipulation of the distance between pattern halves within the projection plane has different, if not opposite, effects. [17]

Fig.5: Mirror symmetry with no spatial separation between pattern halves, digital 3d study model, experiments stage II/ Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

Point 8: The pattern behind pattern

Symmetry can help us towards a journey of reestablishing the inherent poetics in form. The lines of a design are extended out invisibly. "Form, I believe," says Cecil Balmond, "is something deeper than what we see. It's a more innate, hidden imperative. Form has something to do with the configuration in space of connectivity. It is the rhythm of those connectivities that provoke deeper resonances, the feeling of deeper archetypes. Form is very complex because it has different layers; it's never a one statement thing." Beauty is mysterious, and hard to pin down, moves on hidden planes, away from the physical fact and the literal towards an inward magnification. It includes small parts of awkwardness along with the smoothness of symmetry. [18]

Using symmetry as a generative process of aligning different patterns of repetition in different ways through an algorithmic logic, products of higher level of complexity that differ from the initial structure and between themselves can emerge. By observing the outcomes of that process, the difference between how it started and how it ended is obvious, while their style of becoming is hidden, sometimes more and sometimes less, but always implying.

Fig.6: Digital 3d study model, experiments stage II/ Final thesis.Fall 2019, post graduate program 'Advanced Design', School of

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Point 9: The tool / Algorithmic logic

It is remarkable that the concept of structural order can be reached from different viewpoints: we can use science to discover how structures are put together coherently; we can use art and architecture to do the same thing. [12] Nature's code influenced design to adopt the idea of digital morphogenesis. Biology, design and ar chitecture are focused among other things, on morphology. That morphological exploration is based on a metamorphosis or a transformation. Morphogenesis, properly applied, would have to enter the realm of algorithmic design as an abstraction of nature's generative processes and strategies, instead of plain verbatim copies of natural form. The aim of design may not be alive constructs, but it could also be structures that possess properties of living systems, rhythms and connection.

John Frazer observed that many of the breakthroughs necessary for the development of an evolutionary model of design occurred outside the field of architecture. In addition to the dramatic achievements of genetics and evolutionary biology, innovations in mathematics, computational modeling and physics provided the impetus for many of the early experimentations with evolutionary design techniques. [19] The onset of computation has, however, offered us the chance not only to reconnect architecture with geometry, but also to realize the opportunities of other branches of mathematics and logic, such as algorithms.

When there is a need for a new way of thinking, we needt o got hrough a "creative generative logical process". By externalizing the architecture of thought in the form of an algorithm through coding, designers are introduced into the realm of digital consciousness. A realm where human imagination's limitations could be ex tended. Algorithms can orchestrate the geometry from the macro scale down to the perplexing level of detail thus uncovering previously unseen aesthetics, blurring structural and ornamental dimensions leading us to an understanding of structure ornamentally. Algorithms in essence, are providing a way of redistribution of the sensible, firstly within the design process and subsequently through the results that they produce. Therefore, algorithms produce new aesthetics beyond the traditional understanding of the term.

If these tools at the beginning of the computer era seemed to threaten human creativity today by allowing us to operate on codes creatively directly, they become tools that open new fields and enhance our understanding of creativity as an indissoluble synthesis between art and science.

Final coding-an experiment

The following example is part of a final thesis, entitled "At the edges of infinity", at the post graduate program 'Advanced Design', at the School of Architecture of the Aristotle University of Thessaloniki, in the fall of 2019. In the experiments different forms were explored by a sequential and procedural methodology using a core algorithm. The core of the methodology was to create an algorithmic process and not a final form, as a generative system moves the focus from static models into a computational logic to a coding of the design intent. The form of what is build, evolved through code as it is build. The source of the morphogenetic process can be found at the multiplicity of elements and local relations that create the order of the system. Emergent structure combines what is already there into a new form. The whole changes according to its context thus it becomes unique through the difference produced by its localized repetition.

STAGE I

In practice, it all began with a sphere and in a sense the final collection of objects is a collection of "twisted", altered spheres. The process began with the creation of an algorithm that interferes with the sphere and alters it.

Fig.7: Altered sphere, digital 3d study model, experiments stage I/ Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

The algorithm responsible for the transformations is split into pieces, into different "actions". There are three basic such actions: First, it operates evolutionarily and as described in its diagrams, the letter G (G1, G2 etc) corresponds to "Generation increase". That means that there is an increase in the number of generations. The number of generations was defined based on the number of faces of the initial sphere. The letter D on the charts corresponds to additional "Data" information. Immediately after a generation increase, all new data is computed and stored (creating a library internal to the algorithm and its function). The letter A on the charts corresponds to "Adaptations". During an adaptation phase, the number of faces does not increase, so we do not change generation. Geometry and spatial arrangement however, can change during that part of the process.

In this process, the algorithm evolved and developed, and through continuous experimentation the objects / altered spheres produced by it, were also developed. The objects that began to be produced, and that retain the characteristics of the initial sphere, are a very small subset of the possible expressions of the first form of the algorithm.

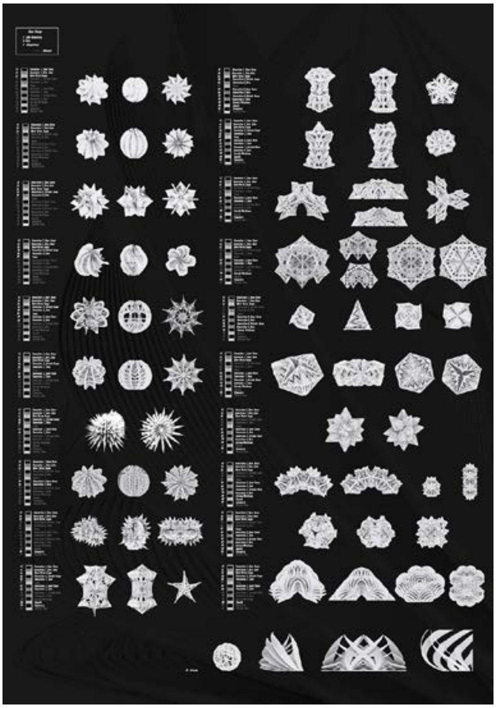

Fig.8: Experiments stage I, digital 3d study models / Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

STAGE II

At this point, the algorithm itself evolved and changed the form of the resulting structures extensivly. In the previous procedures, a logic of flocks was added. From selected vertices of the sphere, agents originated based on the normal vectors of these vertices, and began to delineate curved trajectories as a result of the rules of the flock. Different parameters were used that changed the fields in which the flocks were moving. The flows produced were then added to the algorithm so that they could be used as a framework which ultimately guides the evolution of the structures. The sphere somehow 'spreads' on the flows. At some point the structures continued to be built in a symmetrical way, thus increasing in detail.

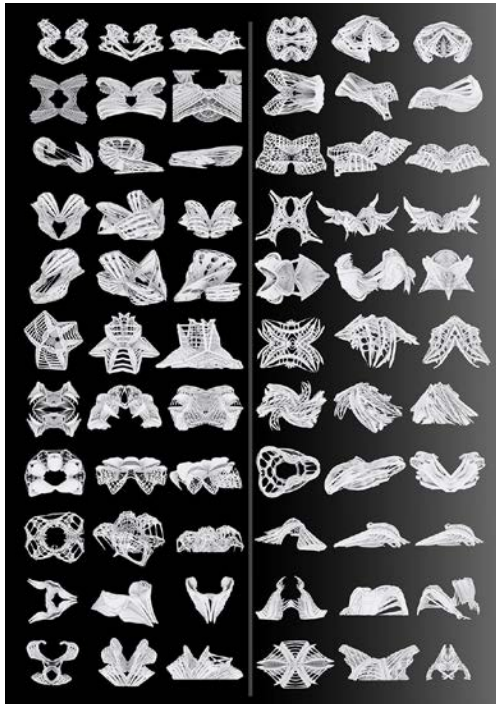

Fig.9: Experiments stage II, digital 3d study models/ Final thesis. Fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

The power of algorithmic design is hidden in the details as shown in the images of both digital and analogue models. The character of the final models and the landscape that hosts them results from a combination of the common history they share and created them, from small doses of awkwardness that results from the unpredictability of the results, and the kaleidoscopic qualities that symmetry added. The difference between how it started and how it ended is obvious in the final collection of objects. All the objects started as a s phere. At the stage I the use of multiple symmetries, patterns of repetition, used one after the other led to the dominance of the kaleidoscopic qualities at the final form, while during the stage II experimentations where the symmetry broke using field effects a different aesthetic were added into the equation. The equation that describes how symmetry through repetition leads to the emergence of difference seems to open up new questions and new possibilities for further experimentations.

Fig.10: Analogue 3D printed models/ Final thesis, fall 2019, post graduate program 'Advanced Design', School of Architecture, Aristotle University of Thessaloniki. Students: D.Alexiou, Instructor: Dimitris Gourdoukis.

"*At the edge of chaos, in areas of bounded instability, on the boundary between order and chaos, there is enough stability to have repetitive and predictive elements in the system, but just enough instability to generate novelty without creating anarchy and di spersal*." (Zimmerman, Lindberg and Plsek, 2001)

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