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Resumo

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MEANINGS AND MAKING SENSE OF THINGS

SIGNIFICADOS E COMPREENSÃO DAS COISAS

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Resumo: O texto reflete sobre o significado da matemática na arquitetura, questionando até que ponto fórmulas, números e estruturas racionais podem realmente fundamentar o sentido arquitetónico. A autora discute a tensão entre certeza e incerteza, racionalidade e subjetividade, mostrando como a perceção, a fenomenologia e a estética influenciam a compreensão das formas construídas. A partir de Husserl, Merleau-Ponty, Leibniz e da tradição helenística, argumenta-se que a arquitetura resulta da convergência entre regras objetivas e experiência sensível, e que o significado não reside apenas nas formulações matemáticas, mas na articulação entre arte, ciência e perceção humana.

Palavras-chave: Matemática na arquitetura | Fenomenologia | Perceção | Estética clássica | Subjetividade e objetividade | Significado arquitetónico | Formulação matemática | Ontologia da arquitetura | Certeza e incerteza | Vitruvius e estética helenística.

Abstract: The text examines the role of mathematics in architecture, questioning whether formulas and numerical structures can truly ground architectural meaning. It explores the tension between certainty and uncertainty, rationality and subjectivity, emphasizing how perception, phenomenology, and aesthetics shape our understanding of built forms. Drawing on Husserl, Merleau-Ponty, Leibniz, and Hellenistic traditions, the author argues that architecture emerges from the interplay between objective rules and sensory experience. Meaning, therefore, does not lie solely in mathematical formulations but in the dynamic relationship between art, science, and human perception.

Keywords: Mathematics in architecture | Phenomenology | Perception | Classical aesthetics | Subjectivity and objectivity | Architectural meaning | Mathematical formulation | Ontology of architecture | Certainty and uncertainty | Vitruvius and Hellenistic aesthetics.

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tiles and topography" (2018); "Euclid and the Illusion of the Rainbow" (2014); "Unificando o Conhecimento Humano: adaptar a espera" (2014); "Serpentine Gallery Pavilion: Essays on Colour Environment" (2013); "Aalto and Kazimir Malevich: Selected Thoughts on Colour Environment" (2013); "Realm Art-Science: By Colour We Think" (2013); "Metagrass or a Tail of a Green Future Environment" (2013); "Euclid and the Illusion do Arco-Íris" (2013); "The Colourlessness of the Zener diode" (2011); "The Image of Lisbon: a criticism on Wim Wenders's Lisbon Story, 1994" (2007).



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MEANINGS AND MAKING SENSE OF THINGS

Mathematics in architecture may suggest a supra-historical sense of architecture due to the role of mathematics in scientific explanation. However, we may say that it is art *in itself* that is supra-historical in a different way than we may find in mathematics when giving science a supra-historical sense. Presence of mathematics in architecture displays a double manifold character of being connected to science (and to all that science can provide), and to art (and to all that art conveys), and yet both art and science do not superimpose upon one another, that is, they have different objectives and meanings.

Unless architecture would absorb perfectly a metamathematical 'language' that would superimpose other creative forms of conceiving architecture, we may conclude that mathematics in architecture has been and perhaps would ever consist of partial references, due to free will and subjective character of creation. We may even think about irrational characteristics insofar as any rational ground may not support the use of mathematics in architecture. Nonetheless, physical constructive properties of materials would be grounds of rationality by all that can be imagined beyond such grounds and may have other characteristics, that would give rationality other expressions, or meanings.

In what might be a difficult assumption, the sense of continuity from science to art might be connected to the role of metaphysics in the development of science that can have guided "obscurely", or "secretly", methods and other ways of exploring the world we live in. And mathematics may have much to tell, or to hide, in this process.

(A POSSIBLE) INTRODUCTION

Are not the important qualities of architecture deeper than meaning? Are not those qualities deeper than the presence of mathematical formulae? They are. Also, similar questions might be put to mathematics. Are not the important qualities of mathematics deeper than those that we may endow with meanings by its presence in architecture? They are.

We may proceed by crossing qualities and meanings on architecture *versus* physics, mathematics *versus* physics, nature *versus* mathematics, architecture *versus* nature, or physics *versus* mathematics, and similar and we will arrive at similar conclusions. We may not seek for specialization as a need according to the pursuit of such conclusions but rather a natural development of each one of them finds its own way.

Then, would crossing possibilities through those different fields be a matter of necessity, a random causality, or rather a subjective choice? And would these possibilities introduce changes in their ontological meanings, or would they acquire extrinsic meanings? Would these extrinsic meanings be connected to ontological meanings, or would a crossing field create a completely alien meaning displaced from any former ontological referential? What seems to complicate the problem is the fact that necessity, causality, and subjective choice may not fall into an objective logical structure. Then, meaning, and meaningless may meet each other with no clear reciprocal answer.

APODICTIC. UNCERTAIN. SUBJECTIVE.

Architecture is not alien to general humanistic problems that can be found in the “exclusive” realm of ideas ranging from the apodictic to the illusive. A basic decision of laying down stone on stone, brick on brick implies decisions, knowledge. However, despite dealing with objective real things that obey physical laws, or properties such as mass, weight, form and shape, texture and attrition, resistance to compression and tension that can underpin rational displacement and organization of parts, it does not mean that subjective decisions may not combine with decisions whose base claims to be rational and apodictic. We may even question to what extent the presence of the subjective may loosen grounds for certainty.

Aesthetic experience moved by emphasizing subjectivity and might have overcome a sense of objective aesthetics. We may regard Gestalt as being on the wake of a scientific base, but phenomenology might be accepted by many scholars as an acme of a movement towards subjectivity. In fact, this was a hard task and Husserl and Merlau-Ponty needed to bring together the extreme subjectivism and the extreme objectivism, otherwise their philosophic prose would suffer a sense of *incompleteness* that eventually could mean nothing but uncertainty. Mikel Dufrenne was able to properly ground the aesthetic experience and we became familiar with dealing with such experience in an equivalent way to that which a scientific reality can provide. Yet, perhaps the most precise and concise idea to ground the apodictic would-be Husserl’s phenomenon of *absolute* consciousness which can be discarded as myth (DALLERY 1990: 35-43). But by accepting *absolute consciousness* as real we will find that any sense of subjectivity would then be granted with a sense of absolute. Thus, subjectivity would leave behind uncertainty.

A FEW PROBLEMS TO REFLECT ON MATHEMATICAL MEANING FOUND IN BUILDINGS

The questions formulated here are based on the extensive criticism that Husserl put forward in *Krisis* and suggests serious misconceptions of the meaning that formulae in architecture can have especially those perceived by the eye. What I suggest here is that Husserl aimed to properly ground perception and psychologism which was a major obstacle to ground sciences even if he treated widely natural and human sciences. But the argument is centred exclusively on the consequences we may find in the notion of architectural reality when we have architectural forms and shapes outlined by mathematical formulae.

Let us put the following problem which is a consequence of the way Husserl’s *Krisis* shook the world (DALLERY 1990: 24-25):

If (1) there is, indeed, a crisis in sciences, understood as a the *Natur- und Geisteswissenschaft* (natural and human sciences); (2) a crisis of philosophy; and (3) a crisis of culture;

If what was lost was, (4) primarily the origins of subjectivity, (5) whose responsibility goes primarily to *numbers and formulae* which also (6) caused natural sciences and human sciences to disintegrate, disjoined, or being disjoined;

If from this state of things, we have to realise that (7) sciences lost their meaning to human life because (8) sciences intrinsically proceed by manipulation brute facts without ever raising questions of value and meaning:

We cannot in any instance fall away from the central role played by (5) *numbers and formulae* and we would be forced to conclude that every historical use of any number of convention or formulae in architecture must lack meaning because the presence of meaning and formulae imported from mathematics of science represents exactly the absence or loss of meaning. It may sound paradoxical that what we add in value represents the loss of meaning and this paradox can only be solved by attending to different ontological characteristics of art, science, and mathematics whose meanings should remain unchangeable to some extent when they meet at crossing roads.

PROBLEMS IN THE NOTION AND ROLE OF PERCEPTION – SENSING THE WORLD

Yet, this seems to be a major concern in the ways we ground our acquaintance, because returning to perception to ground knowledge might not solve the problem. There is a contradiction on what should and what can be perceived. In the Renaissance, perfect acquaintance with the object by entering a church would mean to be familiarized and to decodify all formulae present and their given symbolism. However, if that would be the case, especially all architects who created temples would suffer from a lack of access to meaning insofar as the presence of formulae, at its best, would symbolise the displacement between subject and object.

In a less radical way we may simply assume that the essence of the building would never be mathematical otherwise it would lose its meaning as a human object even when the architect decides to prescribe *number-formulae* data to organize the composition of the building. This goes further, the golden section cannot be understood as the essence of the building even when it is displayed.

This seems valid in the context of contemporary architecture where algorithms may create forms, but we may never be acquainted with those formulae that provide forms and shapes unless we are deep in the process of creating them. In this sense we may assume that those formulae may not confine deeper meaning in architecture.

However, usually we easily find the key to those formulae because architects like to describe their building which is a practice that we can trace back to Greece and to the genesis of the theory of architecture such as we know it today. Yet, describing the algorithm by presenting a formula and accepting it as the final accurate description would mean that we are centring the deepest meaning of architecture in mathematic formulae. Indeed, we are assuming that formulae describe buildings better to an extent, and that perception alone cannot. Thus, shapes and forms might be attractive, but it may not be clear where, how and why we should centre the origin of architectural meaning. Moreover, if we accept that is the architect is the key actor here because he can decodify what the perceiver cannot, then, the role of the *subject-perceiver* is of lower importance even when it is the destination of the object because his perception would always be incomplete.

Returning to perception and being more radical, phenomenological inquiry may have found serious implications and problems especially when assumed as a privileged form of *giving meaning*. Because it is not sharply clear how sense experience is the fun-

damental one, as mathematical formulae will only ever describe better what perception cannot. Furthermore, even the sense of completeness is given only at a final stage by what mathematics can describe. We may have Merleau-Ponty in mind and rejecting that reflection a posteriori would legitimate perception and that all begins in perception, however, it seems hardly avoidable that there are meanings that are not given by perception, and we may question if it is perception that really grounds those meanings.

Certainly, all these formulations might be challenged by architecture and architectural experience. *Trompe-l'œil* is centred by deceiving the eye and emphasizes vision as the privileged way to experience space. As we have moved from one vanishing point to two or four, we have also left behind the *quantum continuum* characteristic of the early perspective whose sense experience was not far away from its mathematical structure. We see it in Raphael's *School of Athens* (1508-1511) where the localization of the vanishing point is clear. However, in the Baroque, in order to have a perfectly deceiving experience of the eye the mathematical framework would need to be absolutely hidden. Thus, what would be a perfect mathematical experience would be nothing but being opaque to it, the laws that created deception. Gian Battista Tiepolo (1696-1770) was a master of this illusion at an age when mathematics was given autonomy through the *calculus* under Isaac Newton (1642-1727) and Gottfried Wilhelm Leibniz (1646-1716).

We can think that absolutely free sense experience seems difficult to archive and that the realm of art enlightens this limitation of perception because artists and architects can determine to some extent what should be and can be perceived. But if this is true and being aware that *trompe-l'œil* departs from reality, how can we grant that reality is always perceived free of deceiving? And how can we grant suitable meanings to phenomena that we have not granted to be acquainted with properly?

Yet, there must be ways of controlling uncertainty, otherwise we are not able to construct anything suitable further on. But we may recall Georges Gusdorf and not being surprised with the role of mysticism as a background to science (GUSDORF 1993). What we may call "rational" might have been elaborated through many different notions.

Last but not the least we may recall Hellenistic-Roman duality objective *versus* subjective and combining these notions with an important aspect of the seventeenth-century aesthetics and we may reflect on the way how theoretical problems may assume different expression in architecture.

"In the 17th century, philosophers began to question assumptions that had hitherto been accepted almost universally. The doubts they raised were of two kinds. Certain philosophers, like Descartes, Spinoza and Hobbes, held that beauty is not an objective property; others, among them Leibniz, held that it is not capable of being rationally grasped." (TATARKIEWICZ 1974: 371)

According to LEIBNIZ (in *Principes de la Nature et de la Grâce*),

"Music charms us, though its beauty consists merely in an accord between numbers, and in the fact that, though our souls prevent us from noticing it, we are continually counting the strokes and vibrations of sounding bodies, which meet at certain intervals. The pleasure afforded the sight by propor-

tions are of the same kind, as too are the pleasures deriving from the other senses, all of which can be reduced to something similar, though we cannot explain what that thing is." (TATARKIEWICZ 1974: 382)

Holding "that beauty is not an objective property" is a stable proposition in meaning. However, Leibniz by stating "we cannot explain what that thing is" can be read as *uncertainty*, or at least *incompleteness*, but the fact that *numbers* and *proportions* exist and are the necessary vehicle to the aesthetic experience cannot be avoidable. Thus, Leibniz solution appears to be more comprehensive, more ambitious because it combines two systems. Firstly, there is a single framework to beauty, and it is mathematical. Secondly, using a number terminology, it is incommensurable even if based upon things that in their own are commensurable.

Regarding baroque architecture and the fundamental role of the *trompe-l'œil* on deceiving (subjective persuasion) and the mathematical apparatus behind that illusion (rational, objective), we may conclude that there was something fundamental in baroque architecture that emanates by the convergence of the two seventeenth century convictions. We would accept the hidden presence of mathematical formulae because beauty is not an objective property. We do not need to display the apparatus such as would be typical in the Renaissance in which precise decorative geometry of pavement inlays would be aligned with and would emphasise rhythms of columns and arches. In this case, such as in the mentioned Raphael's School of Athens the *geometrico-mathematical* apparatus would be obvious.

Secondly, there is a "more serious" reason which can be regarded as a *loss of certainty* in mathematics. Even knowing that beauty arises from numbers – mathematical formulae – we would not be able to be conclusive about an intrinsic value that brings together the subject and the object. However, it can be suggested that it is precisely this loss of certainty that enabled architects and artists to explore further mathematical formulae in architecture and thus giving spaces their vivacity. Architecture might have "solved" the problem of subjectivity *versus* objectivity in its own way and the conceptions of mathematics regarding aesthetics were fundamental in this process.

CLASSICAL AESTHETICS AND VITRUVIUS ON ARCHITECTURE.

We would like to emphasise that the problem of objectivity *versus* objectivity is not new and Hellenistic aesthetics was able to combine them, organized them according to a hierarchy and thus making both approaches operative and meaningful. Mathematical formulae appear somewhere in this process. But certainty was not granted by mathematics alone but, perhaps, by a basic rational conception of the world and posture regarding reality that would also comprise mathematics.

Problems regarding the apodictic, uncertainty and subjectivity may be found in the way classical aesthetics were organised and we may reflect on their consequences that may even be found today. An approach to this problem is to think about what was rational and what was understood as subjective and how they have organized the duality, rational-subjective in a way they could work with these notions together while conceiving and constructing buildings. Rational is the realm of a set of rules while

subjective arises from experience, from the way we directly fashion the world and art. The easiest way to find and proceed from a set of rules was understood. And this was framed upon mathematical systems which need invariable symbolic schemata to grant a permanent relation through those symbols. These facts have consequences in the way we may oppose experience to reflection and has had consequences in art and science.

“... at quite an early stage, the Greeks evolved two types of culture, the Dorian and the Ionian. The Ionians preserved more Mycenaean culture and also came under the influence of Cretan culture and the culture of the flourishing civilizations of the East in whose proximity they had settled. This duality between the Dorian and the Ionian culture dominated Greece for a considerable time and is discernible in her history, particularly in the history of her art and theory of art. The Greek search for constant norms in art and immutable laws governing beauty stemmed from the Dorian tradition, while their love of living reality and sensory perception stemmed from the Ionian tradition.” (TATARKIEWICZ 1970:13)

We hardly conceive subjective experience emanating from a set of *geometrico-mathematical* rules and yet the sense of freedom to be found there must be different, has to be different while arising from the rational or, either, from the subjective. Existence of rules may not mean a lack of resources to explore meanings and a subjective base may not come to an end where meanings were so opaque that they cannot be shared by individuals. This possibility that even a symbolic agreement that makes language possible – and thus communication – would be impossible.

What is particularly challenging is the fact that, in itself, the use of a particular set of rules – therefore rational – might be nothing but a subjective choice. Often, it seems not so grounded, decisions that we can identify either as rational or subjective. Yet we may think about subjective and rational criteria and about ways in which we may combine and organise them. But from the outset we may keep in mind that such a working framework should have some symbolism and even principia that in its origin may take us to field such as mathematics.

Vitruvius's *Ten Books* reflect not only Roman aesthetics but especially late Hellenistic aesthetics where we founded the basis for his writings.

“To a great extent Vitruvius’ analysis of architecture lay within the technical field of Hellenistic aesthetics, as opposed to the humanist standpoint adopted by contemporary philosophers, poets, rhetoricians, and even painters and sculptors. In architecture, however, the problems were somewhat different. There was no dispute over whether form or content should take precedence, whereas both the social and optical problems of aesthetics were prominent.” (TATARKIEWICZ 1970: 274)

Consequently, architecture appears to them as a possible source of objective knowledge where we may combine different aspects of rationality. Such tendency

would have been of great importance since the meaning of architecture was wide ranging. According to Tatarkiewicz,

"What the ancients called "architecture" actually consisted of the sum total of technical knowledge which included building (*aedificatio*), clock-making (*gnomonice*), the construction of machines (*machinatio*) and the building of ships (in Vitruvius' work only this last is missing). Building was divided into private and public, and the latter was in turn divided into buildings which served defence (*defensio*), worship (*religio*) and the requirements of public life (*opportunitas*). Tombs as well as temples and altars were included among structures of a religious character, while the *opportunitas* category included ports, squares with depots and basilicas, offices, conference halls, prisons, granaries, arsenals, theatres, amphitheatres, odeons, stadiums, hippodromes, gymnasiums, palaestras, baths, wells, cisterns and aqueducts. All this variety was a phenomenon characteristic of Hellenistico-Roman times in contrast to the early Greek period when architecture was in practice confined to temples." (TATARKIEWICZ 1970: 270-271)

This vision implied that what was expected from an architect was very demanding and embraced many fields that in a contemporary sense we have no longer placed together. It is, somehow surprising that architecture was not placed among *studiis excellentes* since the pure theoretical knowledge (*ratiocinatio*) was required for the foreman. And the "Greek word for "foreman" (*architekton*) has given the whole art of architecture its name." And most building workers were called *fabritektones* where *architekton* was differentiated by his responsibility and leadership and the latter would need to be intellectual too despite of other skills we would need to possess.

Characteristic of Vitruvius is the necessity of combining aesthetic character with technical character and thus we have as fundamental stability (*firmitas*) and usefulness (*utilitas*) and beauty (*venustas*).

"He distinguished as many as six elements of architectural construction: *ordinatio*, *dispositio*, *symmetria*, *eurythmia*, *decor* and *distributio*. These terms have no precise equivalents in modern architectural theory; *ordinatio* may be tentatively rendered as "order", *dispositio* as "arrangement" (or rather, "proper arrangement"), *decor* as "suitability", *distributio* as the "economy" of a building. We have to retain the original Greek terms of *symmetria* and *eurythmy* because no modern term conveys their special meaning. Vitruvius and other Romans also failed to find suitable Latin equivalents. *Non habet Latinum nomen symmetria*, writes Pliny. These two concepts had a general aesthetic application, whereas the remaining four were concerned specifically with architecture." (TATARKIEWICZ 1970: 272)

These are the known concepts and any study on Vitruvius would strongly focus on them, often exclusively. However what Tatarkiewicz explains is the ability to understand them deeply with their nuances and keep them apart from their readings a

posterior even if it was exactly what was made *a posteriori* and, last but not least what we are doing through these lines. At the present, this further analysis represents the search of how and to what extent different aspects of art and architecture could be combined and how mathematics plays a role in them.

The Hellenistic apparatus was quite complex, and we know that important writings were lost, but statements regarding aesthetics are found throughout philosophic writings. Vitruvius, being himself an engineer, laid down data precisely as well as we identify their origin. Such precision is also found in Euclid's *Elements*, but the origins of geometry have to be found in a broader way, for instance by realising the way in which the Greek emphasised their Egyptian and Babylonian background.

We will proceed through three groups of concepts according to which we may organize Hellenistic-Roman aesthetics:

"The first group included concepts denoting that which pleases the eye, above all the two concepts of *aspectus* and *species* (prospect and shape), both essential to the aesthetics of the visual arts. An even more general concept denoting visual beauty was *venustas* (*symmetria* belonged to a different group), while *elegantia* was applied to a more precious type of visual beauty. In this group we may also include another concept used by Vitruvius, namely *effectus*, that is, the effect of a work on man." (TATARKIEWICZ 1970: 274)

We may see this group as made from a combination of subjective factors which by being centred in vision would make visual perception subjective. However, we may ask if there would be other characteristics of art and architecture which, not being subjective to the glance would be confined with aesthetic pleasure and thus being able to think of subjective versus objective aesthetics. Proceeding,

"The second group included the concepts of relation, number and measure, which decided of the success and the beauty of a work. The foremost concept was *proportio* and others included *commodulatio* (i.e., the employment of a single module, a single measure), *consensus membrorum* (agreement of parts among themselves), *convenientia* (suitability of parts), *compositio* (order), *conlocatio* (disposition) and *commoditas* (accordance). All the terms of this series are related, first through the common prefix *con-* (together). Some (*commodulatio*, *commoditas*) are derived from *modus*, one of whose meanings — and the meaning applied to it in architectural theory — was "measure" (TATARKIEWICZ 1970: 274)

Conclusively, Tatarkiewicz criticizes the relationship between the first and the second group,

"Just as the first group covered sensory qualities, so the second group dealt with rational ones. This duality is quite natural. Ancient theoreticians were aware that architecture pleases either because it gives the spectator direct,

sensuous and visual satisfaction or because the spectator recognizes in it proper measures and successful solutions.”

This is particularly important because not only Greeks evolve two types of culture, Ionian (stressing reality and sensory experience) and Dorian (constant norms in art and immutable laws governing beauty), but they could combine subjective and rational characteristics of aesthetics in art and architecture. And since this capability of conciliation seems far more simple and easy to construct in art and architecture than in a pure world of ideas we may not dismiss this importance when we reflect upon mathematical formulae in architecture, in the sources and fundamentals.

“Vitruvius had yet a third group of concepts. These had a social character and pointed to the social conditioning of good architecture. They included such concepts as *probatio* (probation) and *auctoritas* (general approval). Just as the first group served mainly to define eurhythmy and the second to define *symmetria*, so this third group served to define the suitability and, to some extent, the economy of architecture.” (TATARKIEWICZ 1970: 274-275)

We could say that according to Viollet-Le-Duc this third group would represent relative characteristics of architecture – we may even say subjective – in opposition to objective characteristics of architecture (such as construction and structure that emanates from objective physical properties). However, we may also think on Habermas and realising that there is a rational framework that organises society and their conceptions and beliefs. Thus, we may think that the third group has a rational body built in it, in what it organizes and the way it organizes. We may not be telling about formulae, but all together, the three groups might be seen as three different *sub-sets* of another set which is architecture itself.

What we are implying here is that what might be seen as mathematical might not be number and formulae alone. In themselves we may say that these three groups are organized in terms of quality and free of quantification. However, they have other properties which are fundamental to further mathematical development. We may see a classification according to symbolism which has an invariable property given to each symbol and this is the reason why we can talk about them separately, in groups, or combine them. And symbolic language is essential to mathematics. Conceptually we may think about the presence of a general *proto-mathematic-like*, though which engages formulae with *number-free* concepts.

According to these ideas a final reflection can be made. There seems to be an *a priori equivalence* between the two systems, the rational and the subjective. This system presents a second important characteristic, it does not separate in theoretical terms, a theory of creation according to which the architect proceeds from a theory of perception – the *subject-perceiver*. Last but not least, we may reflect that if the importance given to formulae in ancient buildings acquainted by the way we perceive them reached such high importance especially because it was not centred in formulae alone. Thus, and contrary to what much literature says, even the golden section would not be the key to beauty even when it is confined to it.

MATHEMATICAL REALISM

Hellenistic art, painting and sculpture was centred in the imitation of nature. Thus, art would be made of beautiful objects, not because there was an intrinsic beauty in themselves but to the extent that they would prove to imitate things properly. What we would find later in the Renaissance, in Leonardo's drawings as in other artists is the search for the ways how nature is and can be represented accurately. In Greece we find mathematical proportions in temples such as we find in sculpture. Thus, mathematics does not display an intrinsic autonomy because it must prove that it is successful as a tool to represent reality. We may also think about architecture as being *an-itself-for-itself* but such characteristic, if it does exist, does not make it useful for representation of nature in art. We then must consider that mathematics in art may confine to the extent that it serves a purpose, very close to what may be meant by applied mathematics.

"Yet other works portrayed the material forms of things not for their own sake but in order to convey psychological facts, that is, character, *feelings*, experiences of people. Instances of this are discernible particularly in Baroque and Romantic works, in the painting of El Greco or Delacroix." (HARRELL 1973: 128)

Focusing our attention on Baroque and taking into account what has previously been observed in the relation between art and mathematics, we can add substantial facts to the discussion. Mathematical formulae in buildings have been put under the service of mental entities which are even more vague than *forms of ideas* and thus indiscernible at the level of geometric forms. These might take us to different questions.

Would mathematics have suffered an impressive loss of certainty? Would we believe that there are psychological manifestations that can be translated into geometric forms? If so, which forms and why any other forms, since we face the problem of the existence of an infinity of forms. But, in the case that feelings cannot have a scientific explanation conveyed by mathematic formulae leading to a form, we have just gone through a path of no return where the only certain thing is uncertainty.

Then, the most plausible validity of mathematics seems to be given by art and to its subjective presence in the art object, or the architectural object. Such a fact is particularly interesting because we can centre our attention exclusively in art and on different possibilities that art has to organize its own system of references, which is so powerful that we can explore metamorphoses in meanings from the uncertain through to the subjective to the rational.

Mathematical loss of certainty would be valid for the present reflection because it emanates from the acknowledgment that reliability of mathematics lies in the immutability of symbols which created a biunivocal crystal-clear rationality symbol-object. Thus, certainty would be automatically questioned when the object is ambiguous even if we recognize that a single mathematical entity, or symbol, can represent different objects. The object cannot be uncertain, undetermined.

SOURCES OF MATHEMATICAL REALISM

The source of *mathematic realism* is *natural realism*, meaning “natural” that originates from *nature* and thus mathematics is grounded on the experience of the world we live in. The “historical origin of mathematics is signalled by our continuing use of the word geometry, the measurement of land” (KLINE 1980: 307). What we have been concerned with is (1) about the way how the knowledge of the experience of the horizontal surface of the Earth was taken to a vertical wall, a column; (2) how other problems were found intrinsically in mathematics favouring its autonomous development; (3) how mathematics appeared at the core of mental entities which were not given neither by the land-wall reference, nor by pure mathematical entities, and (4) questioning if mathematics has moved from an original properly grounded certainty to a loss of certainty. The highlighted duality of Greek culture was particularly important in the evolution of this process and the arguments came to be centred in art and architecture.

This source has another characteristic which is the “*oculocentrism*” (Casey 2007: 172). The presence of visual perception over other sensorial experiences may not be displaced from the presence of geometry and the use of mathematical formulae in art. “*Oculocentrism*” combines with geometry in diverse forms and these combinations seem to be free of limitations. We can regard the geometrical approach of Baroque simply as a phenomenon created by this interaction.

We can understand several combinations of systems, but soon the outcome of non-Euclidean geometries went further in showing “that the axioms of Euclidean geometry were not truly solid strips of earth but only seemed so on superficial inspection” (KLINE 1980: 308). The problem seems particularly deep since we may formulate a sense of an *universal* ideal of absolute beauty. But how can we accept such a notion if the mathematical apparatus which we have used to describe is not universal? Thus, if the legitimacy of art consists primarily of a mathematical content, we may be forced to conclude that all previous art production was incomplete in terms of human fulfilment. However, by reversing the problem and departing from forms of aesthetics whose legitimacy would not depend on the primacy of mathematics, we would not face this problem of loss of certainty in art due to a loss of certainty of mathematics.

RECOVERING CERTAINTY IN STRUCTURAL CALCULUS

We know that Guarino Guarini was a remarkable mathematician and that he used calculation tables in his buildings, but they have been lost. His structural calculus was precise and conjugated with targeting psychological experiences. Consequently, it would not be surprising that in the following age mathematic certainty will be rebuilt afresh from structural calculus.

Henri Labrouste (1801-1875) read classical proportions as constructive-structural related which was an idea initiated by the neo-classicists in its own way that included clarity of forms and the abandonment of ambiguous systems of cargo and support. Thus, identifying a clear distinction between what is a column and a wall and what these both respectively support.

It is mathematical certainty that makes the new iron-glass structures possible and represent, according to Christian Norberg-Schulz, the true creative architecture of the nineteenth century (NORBERG-SCHULZ 1988: 173-175). And such methodology can embrace all materials ancient and moderns, as also recovered ancient technologies afresh. Calculus can embrace and underpin any kind of material and structure to fulfil any kind of typological destiny being it bridges, private or public buildings, and so on.

These mathematic possibilities came along with a change in the conception of nature to be seen as a system of processes centred in energy. And only mathematical formulae seem accurate to both. Thereby, describing and understanding such processes question the privileged position of *oculocentrism*, in relation to its capability to describe and understand nature.

The steam engine invented by James Watt (1736-1819) also placed mathematics in the centre of the new industrial civilization. Many considerable accidents occurred because his calculus was not respected. Reliability of mathematics seemed easy to acknowledge in this new practical era.

However, the rational and the subjective did not vanish from aesthetics. The question concerning the architectural form, whose substantial base would need to be fundamentally its constructive and structural character, or other rational base (such as function), or rather a subjective, or even ambiguous base would continue throughout the nineteenth and twentieth centuries. Briefly, Modern Architecture was concerned with the expression of a rational base, preferably scientific and Robert Venturi questioned the illusive presence of such rationality through history.

This opposition, duality, or conflict comes from the stream of time, what is seen and what is hidden. We do not see and hardly guess the calculus of a truss if we are completely alien to its reality. We may have a general idea of the adequate sections of the parts of the truss, but we may also think about the number and section of the rivets. It is rather complex unless we are familiarized with the properties of materials, their possible geometries, and the ways they can be assembled. Mathematical formulae are hidden, and they are confined to the properties, shapes and forms of materials.

However, the problem is how far can we make *tavola rasa* of subjectivity. And if we do not, not only mathematics moves out from the centre of architecture, but mathematical formulae would be more permeable to be allocated in different ways into architecture.

CONCLUSION

The presence of objective (rational) and subjective approaches to architecture is widely historical. We find this duality comprehensively detailed as early as ancient Greece where they were able to, not only formulate the two systems, but also to combine them and work with them successfully.

There are different forms of rationalization and mathematics is only one of them. Subjectivity itself shows to be effective when organized by a rational system of its own. Furthermore, it would have been probably impracticable for the Greek to work with both systems if they would have not been able to organize subjectivity.

Objective *versus* subjectivity seems central in order to avoid uncertainty. Phenomenology itself and beginning with Husserl needed to find ways to combine them. Certainty being the *opposite of uncertainty* might have other names such as *absolute* which brings about what we *actually* can define as absolute. This is a base of the system, and it is a symbol in itself that would determine all outcoming symbols as well as their meanings.

Combining architecture with mathematics might not be so clear when inquiring where the meaning comes from. Moving from one basic referential to another, from art to mathematics and *vice versa* elucidates the impossibility of reciprocity of meanings, of biunivocal meanings that give symbols absolute unchangeable meanings. This is a completely different behaviour from that we may look for in tensor analysis. By working out the permanence of physical laws from different referentials. "Physical laws, if they are to be valid, must be independent of any particular coordinate system used to describe them mathematically." (MURRAY-SPIEGAL 2009: 189). This fact may put in evidence that mathematics *serves* architecture in a different way that serves science and therefore, the presence of mathematics in architecture cannot be legitimised by scientific acquaintance. Furthermore, architecture cannot be scientific even when using scientific data.

But we need to see and experience the building. A single example may be appraised. Tadao Ando's *MPavilion 10* (2023) in the public Queen Victoria Gardens in Melbourne – in the Eastern Kulin Nation – uses simple geometry to define grounds and ceilings (<https://mpavilion.org/design-tadao-ando/>). The concrete or simply the sky – wall and water create boundaries and distances, path across the space, colours, and textures. Water follows gravity as it also reflects colours and textures, the wind, or its absence. The heat may radiate from the walls in different ways than it radiates from the grass, from the water. There are smells in the air. Walls are partial obstacles to the breeze, or wind, and to the way how smells flow. Different kinds give different sense of distance through the atmosphere. Yet, all together, the visual geometry is simple, and objective and it hardly comes to our mind what mathematical formulae have assembled the structure together. Much of the objective geometry was enlaced to arouse the senses and to serve feelings.

Finally, this short description actually combines objective and subjective aesthetics. It is somewhat ambiguous but perhaps does not lack certainty. It suggests the presence of the subject, but also emphasizes the presence of geometries which are invariable and do not depend on this presence. Characteristic of the phenomenon of objectivity *versus* subjectivity in architecture, would be that it makes possible numerous descriptions emanating from different bases. But what makes the architectural object central would not be the necessity of the acquaintance to begin with sensory experience. Indeed, we can depart from formulating and reflecting on mathematical reality to achieve that goal. All these types of processes can access meanings and either accept or reject them. Thus, from the production of the actual object through theoretical inquiry we have a rich substance to ground us, in art, aesthetics, mathematics and science, and history.

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