The Value of Mathematics and Computing in Contemporary Art

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Beauty and Mathematics

By

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GENERAL FOREWORD

There is no well-born soul who has never been sensitive to Beauty. This book is dedicated to them, those who question the reasons, the 'why' of the expression of such a feeling. Undoubtedly, other studies could be carried out on this same theme, modifying or supplementing that of the author. In this current phase of reflection, the book is a step on the way to deepening our knowledge of the springs of psychology. As such, it could therefore interest the philosopher, the psychologist and the pedagogue, and of course the artist.

The artist, through his gifts and his sensitivity, has always used the technical means of his time to share his reactions to the most varied manifestations and creations of his environment and his own imagination. In our modern world, computing and mathematics bring totally new elements every day: they enrich the panoply of tools that the artist can deploy. The purpose of this work is also to try to make known, to have recognized, both by the public in the broad sense and by the most devoted animators of cultural life, the immense artistic qualities and intellectual values of the works newly created under the impetus for the progress of our knowledge.

May the reader, through the discovery of the works presented in this book, feel carried away by the breath of this journey and discover and admire the richness of the works of art of our contemporary artists.

From a technical point of view, the book consists of two main parts and an appendix. The prologues that precede each part are intended to be both a sometimes very brief summary of their content, as well as a first justification for their presence. Clicking on their address gives access to the different websites.

FIRST PART

THE FOUNDATIONS OF THE CONCEPT OF BEAUTY

FOREWORD FIRST PART

Beauty, we often talk about it and with an immense feeling of satisfaction. But what is Beauty? Literature is at a loss to define this term. On the definition of this term, all literature is silent and known to yours truly. Thus did not approach the question neither for example the works cited in K. Svoboda's chapter on Beauty[1], in particular Plato (*Hippias Major*) and Aristotle, nor the *Traité du Beau* by the famous Diderot. According to him, "Saint Augustine had composed a treatise on the beautiful, but this work is lost" (Diderot, 1973, 14). Perhaps it is the work that Umberto Eco quotes in *Art and Beauty in Medieval Aesthetics*: "In his treatise *De quantitate animae*, Saint Augustine had elaborated a rigorous theory of beauty conceived as a geometric regularity" (Eco, 1997, 77): apparently there is no precise definition in the background.

The first chapter of this first part therefore focuses on the content of the notion of Beauty, the reason for its presence. We will not discuss here the examination of the very close neurological and biochemical mechanisms - linked to the expression of Beauty - which underlie the expression of two opposite reactions, two forms of amazement, Fear and Admiration. They can place us in truly cataleptic states. Our knowledge of their physiological support is still too weak to talk about it in a comprehensive way that is beneficial to our understanding. We will simply focus on emphasizing the common ground in these behaviors behind which lies the universal notion of *stability*[2]. And it is on the only admiration leading in its absolute version to the expression of an ineffable Beauty that we will pay our first attention to.

This Beauty generally finds its expression in what is called the Work of Art. A brief second chapter recalls some first properties, elementary and essential, while the third chapter exposes "Some characteristics common to artistic activities".

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[1] https://digilib.phil.muni.cz/_flysystem/fedora/pdf/118689.pdf

[2] On the generality and importance of this notion, the reader can consult: *The Principle of Stability, an Essay on the Incarnation of the Notion of Stability within the Pantheon of Mother Ideas* Cambridgescholars.com, 2021 (https://www.cambridgescholars.com/product/978-1-5275-6857-0).

After a very brief historical review on the impregnation of mathematics in the visual arts in particular, the fourth chapter, "Art and Mathematics, intimate links", completes the previous chapter by recalling the place occupied by symmetry in the natural world and so in its representations.

The last chapter of this first part, "The Feeling of Beauty among Mathematicians", addresses the question of the emotional relationships that professional mathematicians have with their discipline, highlights the main reasons that motivate their adhesion, sometimes enthusiastic. We quote the glowing words of some famous mathematicians. The inventory is far from exhaustive; not to share them, are for example absent the views and theories of George Birkhoff, renowned mathematician of the last century. Grothendieck seems to be the most recent mathematician to express his feelings vividly.

CHAPTER I

THE CONCEPT OF BEAUTY[1]

1. Introduction

Smile,

This beam of light that illuminates the face,
Revealer of hidden knowledge,
A knowledge acquired,
Through past suffering,
A source of understanding,
The depth of understanding
Unfolds in acts of Kindness.

That's all, the smile.

Goodness, can we qualify it? Is it happy, radiant, or sad? Interested or disinterested? Linguistic error.

Goodness is characterized by the acts it engenders, not the particular qualities of their authors.

These qualities color every private act. The manner in which the act is performed reveals them.

These acts all respond to the same primary motivation, the same primary purpose of the authors: to contribute to the improvement of the status, the situation, the condition, the fate of their recipients. And through the relationships that these recipients maintain with their family and social environment, in a more global way, they contribute to maintaining a good balance between individuals and the community. What is also called the Good of society.

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[1] The reader will undoubtedly enjoy enriching this text with the many examples with which he is familiar.

The Good relates to the acts, the Good relates to the state.

We admire the success achieved by the acts of Kindness.

More is the admiration that the success is great, the accomplishment of the deed, perfect.

We call it beautiful.

So many objects can carry the quality of beautiful, that we have reified the qualifier, created the name of Beautiful, introduced the concept of Beauty.

2. Nature of Beauty[2]

Beauty is associated with a strong positive feeling towards the object. It translates, represents in a single expression, a single term, by a single gesture of speech, a particular set of effects on the body and on the mind, through sensations generated by the presence of certain objects in our environment.

She is very beautiful, he is less beautiful, we can hear. Beauty, but of course also Goodness, naturally admits nuances in the degree of feeling. Opposed to Beauty is Ugliness, whose powers are contrary to those of the Beautiful, but I will not sadden the reader with such topics here.

The qualification of Beauty is relative to person and object. What properties of objects would favor the birth and development of the impression of Beauty in most individuals? Under what personal data and influences would the qualification of Beautiful be put in place and affirmed in individuals?

Given the immense diversity of objects, of classes of objects, of their no less different properties, being able to provide a first element of an answer to the first question presupposes knowledge of what could appear as common properties, felt as more or less beautiful. Natural material objects, for example a stone, a cloud, a tree, an insect, would they share such properties with these intellectual objects that are for example the contents of our works, the texts of law, the novels, the books of anatomy or physics?

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[2] We will not repeat here certain philosophical definitions of Beauty (for example Kant, Schopenhauer) present in A. Lalande, *Vocabulaire technique et critique de la philosophie,* Presses Universitaires de France, Paris, 2006.

Among the properties of both are those of their constitution, and those of their functional use, intimately linked to their constitution.

Looking at this constitution can give a glimpse of the functional role, can then give hope of benefiting from this role when it brings comfort, physiological and psychological help, in other words promotes the permanence of the being in its environment with fluctuating contours.

This potential contribution is in a way the meaning of the object for his observer. And of course, the greater the comfort estimated or perceived, the greater the help expected or received, the greater the contribution to maintaining the integrity of the person, the more the object will be appreciated, praised.

When a threshold of interest is crossed, a threshold originally determined by the properties of our intrinsic physiology, a threshold which evolves with age under the influence of knowledge acquired personally and/or through influence of the social environment, then a neural disturbance may occur spreading, invading some bodily elements in the form of a discreet heating of the body, the appearance of a smile, a more intense and brighter look, a sound emission releasing internal tension and expressing the pleasure and satisfaction of the individual, in the immediate future or in a more distant perspective.

For current material objects, the shape, the color, the sounds they can emit are the most common and immediate characteristics of appreciation. These same characteristics are present in intellectual objects.

Because behind the apparent form is present the structure, the architecture, the composition, as Rimbaud noted, the letters have a color and a sound, and this is also true of words and sentences, the best poets are also painters and musicians. These characters, when very marked, tend to elicit the most spontaneous reactions, which can be very lively, those fiery exclamations, “How beautiful!”, “Gorgeous!”, “Extraordinary!”, endowed with a real communicative power.

Only fairly rare objects are capable of eliciting such strong reactions. These objects qualified as Beautiful are therefore singular - singular objects occupy a central place in the universe of mathematical objects.

The originality in their conception and the perfection in their realization, rare by nature, are thus criteria almost universally present, attached to the Beauty attributed to these objects.

3. Synthesis, the fundamental concept of Stability[3]

The universal fact that every object strives to maintain its presence through space and time, in other words to preserve its spatio-temporal stability, goes back to Plato. Rereading all the previous considerations, we become more aware that the main reason that leads to the notion and affirmation of Beauty, of the presence of Beauty, comes from the impregnation of the sensation of a renewal of stability, a felt stability, immediate or future, local or global, in the presence of singular objects or events.

The expressions of the Good, the Beautiful, the Good are relative to the search for Stability, stability of the person, of the Me, stability of his entourage, of the local or global community, of society.

4. Complement

The qualification of Beauty does not apply only to material or intellectual works. It also refers to individual or collective behavior related to the stability of society. We generally mean by moral values, or even values of a society, one or more characteristic traits of these behaviors (honest, courageous, generous, etc.) associated with works that I will qualify here as moral.

A work is generally considered beautiful only by a fraction of the population, and very often also only for a limited period. History first remembers the exceptions. We will note here the different ways in which society honors these different impregnations of Beauty: immediately by a financial recognition of generally decreasing importance when one passes, via intellectual works, from material works to moral works; in the longer term, it is primarily the authors of the finest intellectual works who, over time, are honored, due to the significant impact of these works on the future and the state of our societies. Speeches and decorations mainly honor great moral works.

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[3] 1) See the reference given in note 1 which appears in the foreword. 2) “The human eye is made to survive in the forest. It is for this reason that it is sensitive to movement. Any thing that moves, even at the most extreme periphery of our gaze, the eye captures it and carries the information to the brain. On the other hand, you know what we do not see? I shook my head. "What stands still, Vadia. In the midst of all the changes, we are not trained to distinguish things that remain the same. And that's a big deal because, when you think about it, the things that don't change are almost always the most important." in Giuliano da Empoli, *Le Mage du Kremlin*, Gallimard, (2022, 111-112).

The ways in which we celebrate Beauty, in its different incarnations, have of course educational value for populations, encouraging them to act in the same way as the exemplary authors whose qualities, exploits and successes we relate.

It is in this sense that we must take this statement by Pierre Vesperini: "Beauty ... is a moral education"[4] (Vesperini, 2021,27). To cite others who agree with him, he quotes Brodsky for whom "Aesthetics is the mother of ethics", or Leonard Bernstein: "I believe with him [Brodsky], as again with Leonard Bernstein, that the teaching, the transmission, the sharing of beauty are at the same time an education in freedom and justice" (Vesperini, 2021, 27). Such a statement presupposes a preliminary quality education on the ways of achieving Beauty, the constraints and the necessities that are necessary to achieve it, among which, of course, those that take the forms of tolerance and respect for the various freedoms.

The evaluation of such educational power under the vague cover of beauty remains problematic. But it is obvious that introducing beauty into educational works can only enhance the penetration of their content.

The characteristic of the apperception of beauty is first of all to divert the mind from immediate worries, to bring it a relaxation, favorable to the deployment of cognitive capacities, curiosity, and faculties of judgment.

[4] See his preface to his book dedicated to the greatest Greek poet *THEOCRITE Les magiciennes et autres idylles*, Gallimard, Paris, 2021.

CHAPTER II

THE CONCEPT OF A WORK OF ART

1. The work as representation

One of the fundamental activities of objects is to make *representations* of their environment, of what populates it, in order to ensure their spatio-temporal stability.

The term representation is ambiguous here. It designates both the process of representation that we will call pro-representation, its components, its mechanisms, and the final result of the process, the representation itself. Pro-representation and representation are indexed by time.

Objects, for us, only exist through the representations we make of them. Each of these representations is associated with one or more properties of the object. These properties can be modified over time, enriched or withered, as well as the representations of these objects. These representations, we will call them human works, more simply *works.*

We will distinguish the representations made in the first degree by our sensory physiological tools from the second degree representations, obtained by the implementation of our intellectual tools. The tree I see, the song I hear, the perfume I breathe are first degree representations of material objects. The words tree, song, perfume are exteriorized, sound, vocal representations of primary sensory representations. Their creation is the fact of our only spontaneous bodily activity.

The drawing of the tree on the sand, the engraving of the bird on the stone are distinct representations from the previous ones because they appeal on the one hand to the intellectual mechanisms of attention which spread spontaneity over time and in new neuronal structures, and on the other hand to tools of expression external to our person. The written words tree, song, perfume are also representations by drawings whose design required more developed attention, leading to the analysis of certain properties of corresponding sound representations, and highlighting some of their properties.

All of these words constitute the vocabulary corpus. As each word corresponds to a particular representation, which can evolve over time, what is called its semantics, its meaning can evolve jointly.

The vocabulary corpus, which also contains the words that appear for example in mathematics, in algorithms, their uses with their material and now electronic media, such as novels, theses, physical models are obviously located in this same vein so rich in second-degree representations.

Apart from spoken words and improvised, inspired speeches, all human works belong to the category of works made by the hand of man, that is to say first of all as resulting from his cerebral work and *in fine* from the work of his fingers - if only when he only needs to press a single button.

There are of course destructive works. The assassin, whose brain can be considered “disturbed”, will use his hands or mainly his fingers to act on the victim or victims, directly or through an instrument, a dagger, a revolver, the decree he will sign, the hands of the executor to whom he will have given the order. Such acts, such works can present appearances of perfection in their realization. This property alone will not be enough to bring them into the category of works of art.

Any act, any work has the property of being a way of psychoanalysis of its author. If you want to look at it the totality of his person is expressed through his gesture.

2. What is proper to the work of art

Is not every activity of excellence considered an art? Are we not talking about the musical art, the pictorial art, the architectural art, but also the art of medicine, the art of diplomacy or, on the contrary, the art of war, and in a more joyful and convivial way the art of the table, that of pastry, of the production of the finest and most sought-after dishes? We will of course be careful not to forget to add to this partial litany, mentions of geometric art, the art of demonstration, the art of calculation, algorithmic art.

So what is an artist? In this most general sense, any person who therefore practices an art, an activity in an exemplary manner, whether welder, mathematician or sculptor. In this matter, we will therefore not make an a priori distinction between the mathematician, the dancer, the architect, the goldsmith or the great chef.

The specificity of a work of art is in particular to have positive, stabilizing effects, both on the author of the work at the time of its creation, and on its environment.

What positive effects, what can their expressions be, what are the particular characteristics of these works that make it possible to obtain them?

One of the first characteristics of a work of art is its *originality*. It is the expression of physical and intellectual abilities of its author, pushed in certain fields to a high level; we often speak of gifts, gift for drawing, gift for music, gift for mathematics, imaginative gift, etc.

This originality is more or less fascinating insofar as it is both the symbol and the expression of an immediate or potential or announced evolution. It is therefore deeply related to the general phenomenon of the evolution of Nature in which we participate in an often unconscious way, with which we are in more or less active resonance. It is probably through the presence of this phenomenon that lies the first attraction for the work of art, through its originality which can prefigure the future, and which invites us to move forward.

That said, the functional role of each domain in which appropriate art forms are deployed, is at the origin of the fundamental particular properties pertaining to the corresponding works. The art of music, for example, undoubtedly finds its main source in animal song, the love song attached to the perpetuation, to the stability of the species, a song of hope, joy or disappointment. One of the primary reasons for the existence of figurative art, which includes geometric art, among others, lies, again, in the need to store in memory and with enough precision the harmful environmental data or useful for the stability of our person and that of the social group to which we belong.

“Everything conspires to arouse attention” (Berlioz, 1969, t.1- 117) wrote the bubbling Berlioz in his memoirs. Ensuring the quality of the realization of a work, the degree of perfection that it must reach down to its details, is a way of establishing the singularity of the work and the interest that it arouses as a result. “Ostinato rigore” wrote Da Vinci in his *Treatise on Painting*. “They gave me a taste for excellence, for rigor: I would never send a fillet of sole to the dining room that was not denervated, an undercooked dish...” exclaims media chef Thierry Marx.

A work is also characterized by the structure of its composition, the novelty and the richness of its themes, that of its harmonics, the musician would say

of its vocalizations, the painter would underline the extent of its palette, its nuances. This apparatus both hides and reveals the designer's sensitivity, the messages he transmits to us, always implicitly, very often consciously.

“The main source of interest comes from the soul,” Delacroix wrote in his diary (Delacroix, 1963, 286). He does not specify what he means or implies by this word “soul”. I will give it here the restricted meaning of effects of all kinds, and ideas, ideas of all kinds, which the most valiant artists share with us, in an obvious or discreet way. Limited in general are the public, by their training, by their knowledge, by their nature, sufficiently penetrating and sensitive to the presence of all these effects, of all these ideas.

The immense variety of sensibilities, that of their degrees, whether the creator or the spectator are concerned, hardly allows the establishment of refined typologies of works of art whose content is always very rich. I like to give this example of expressions of very different sensitivities. I quoted Berlioz earlier, without any affinity to German philosophy. I will oppose to him this critic of Friedrich Nietzsche, Wagnerian conductor Furtwängler: in a dry word, he settles his account with “Shakespeare is also the theater – it is only that –” (Furtwängler, 1979, 254). But on the contrary, what a pleasure to listen to Berlioz: “Shakespeare, falling on me unexpectedly, struck me down. His lightning, opening to me the sky of art with a sublime crash, illuminated for me its most distant depths. I recognized the real greatness, the real beauty, the real dramatic truth.” (Berlioz, 1969, t1-125).

The richness of the content of a work gives it a power of expression that can inhibit or, on the contrary, forcefully excite certain reactions. By focusing all the attention on it, it helps to free the mind from the worries of the moment. In this sense, it brings relaxation and benefits, it can charm, even bewitch. It entertains.

It is this entertainment in the first sense of the term, this entertainment so necessary to the balance of individuals and societies that ensures their sustainability to all artistic movements, their celebrity to all the arts.

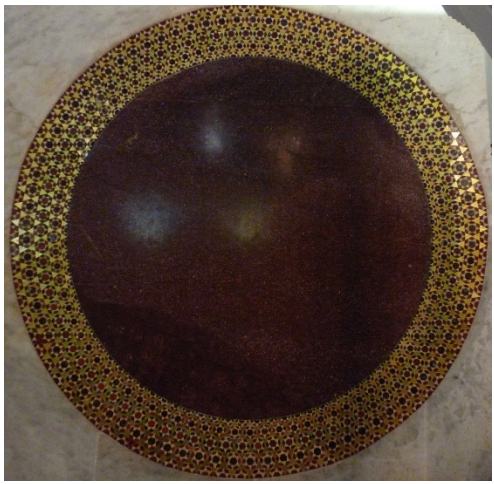
CHAPTER III

SOME CHARACTERISTICS COMMON TO ARTISTIC ACTIVITIES

We can distinguish six characteristics common to artistic activities. They can be given the names of *Representation*, *Perfection*, *Inventiveness*, *Singularity*, *Universality*, and *Wave Phenomena*. The first and last of these characteristics are arguably the most important.

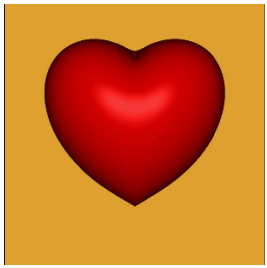
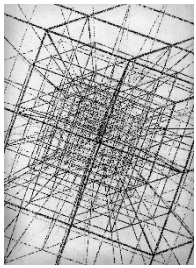
1. *First point,* the common activity of representation. Why do we represent, what do we represent?

2. *Second point in common*: concern for perfection and finish, as can be seen by admiring, for example, this admirable mosaic from the twelfth century,



1. Palatine Chapel, Palermo

or for example these three works with a mathematical foundation, that of a sculptor on the left, that of mathematicians in the center, and that of an engraver on the right:

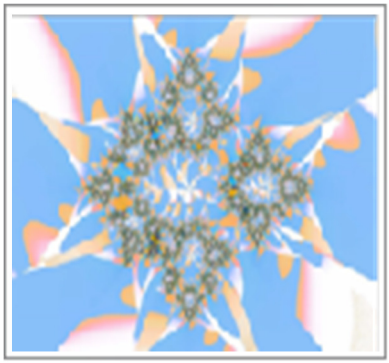
2. John Robinson[1] (1935-2007) **3. T. Norstrand – B. Hunt** **4. Patrice Jeener**
Immortality **$(2x^2 + y^2 + z^2 - 1)^3 - 1/10\ x^2z^3 - y^2z^3 = 0$** **Tiling of hypercubes**

The attention, the care that the figurative artist brings to the realization of his work are guarantors of its quality, immediate testimonies of the high value of his know-how. Any apparent defect, any design error would be immediately sanctioned.

It is the same in mathematics where the work consists in the introduction, the description and the explanation of an abstract datum. The concern for perfection appears not only in the linguistic quality of the exposition, but mainly in the absence of flaws, however slight, in the explanation, called in this case the demonstration. When several proofs can be put forward, the shortest, the most astute of them are often called elegant. The concern for perfection is accompanied here by the conscious consideration of forms of optimality in obtaining results. From these combined qualities can spring the expression of Beauty.

3. *Third point in common: the inventiveness and fecundity they demonstrate.*

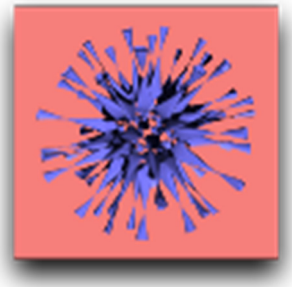
[1] Image borrowed with the permission of Nicholas Mee (http://www.virtualimage.co.uk/nickmee/html/virtual_image_1.html).



5. Mikaël Mayer
(((0.3+1.28i)*(argch(arcsin(exp(x)))*exp((3.16-2.44i)+y))+argsh(z^4-z^(z))*argch(z^-4))/2,6)*0.5

6. Anatoly Fomenko
Sphere eversion

7. Le Douanier Rousseau
The hungry lion



8. Bruce Hunt
A Chmutov octic with 112 nodes and the surface of degree ten with 345 nodes

Mikaël Mayer is a computer scientist, Anatoly Fomenko a Russian mathematician, recipient of several prizes, Le Douanier Rousseau a famous painter of the end of the nineteenth century.

Le Douanier is certainly less inventive and less fertile than Pablo Picasso, author of nearly 50,000 various works! It is chosen here because, through its imagined vision of the virgin forest, it recalls the inventiveness and fecundity of this great inspiration and creator, Nature itself. It is this capacity for invention, this fecundity that characterizes the great work, the great man.

Anatoly Fomenko creates without retouching, which is amazing. He offers us here an original presentation of the different stages of the eversion of the sphere, somewhat removed from the implementation (very technical and very learned) of the equations and the programming making it possible to follow the progress of this reversal (it is a question of ensuring that after turning without tearing among other things, the inner face of the sphere is found on the outside while the face initially on the outside is ultimately the inner face). Invention is first present here in mathematics: posing the problem, finding ways to solve it, implementing them. The imagination shown by the artist here in the elegant way in which he presents the different stages of the eversion is an obvious example of this astonishing capacity for invention of the human spirit.

Mikaël Mayer's work bears witness to the inventiveness of mathematicians and, one might say, mathematics itself. It is the program imagined and built by the creator, its content which, here, by its combinatorial capacities and its random behavior, generates a crowd of drawings and patterns. The author then chooses to show us those that seduce him with their intrinsic aesthetic

qualities. While in the two previous works, the hand of the artist is eminently present in the final stage of the material realization of the work, a new step is taken here towards the detachment of the bodily function associated with this realization.

The last work is apparently more classic, a kind of burst bell that fills the space with an immense bluish background sound. This surface belongs to a whole family of mathematical objects defined by polynomial equations, obeying precise rules of symmetry which strongly contribute to giving them aesthetic qualities. The inventiveness here is that of the mathematicians who ask themselves good questions, it is also mathematics in itself which makes us discover these rich surfaces whose elements are assembled in an often unexpected way.

As for mathematical works, they have an advantage over works that do not comply with their constraints, because the richness of these mathematical works is obviously linked to the infinite potentialities brought by the infinity of numbers. For example, a new surface is obtained by replacing in the previous Barth surface equation one of the numbers 2, 4, 6, 8, by another number, whatever it may be. To paraphrase Shakespeare, perhaps with his permission:

> "*There are more things on earth and in mathematics, Horatio, than are dreamed of in your philosophy*."

4. *Fourth common point: the singularity, originality and relevance* of the works that make them so attractive and so important.

If each work is singular, some have more characteristics of originality than others. This is the case with most of the works of Dali (1904-1989).

9. Dali. Cygnes réfléchis en Eléphants, 1937

Here is a well-constructed work: a vertical axis of symmetry, another horizontal, marking the limit of the sky and the sea. And then this projection of the sea inside a cove: surrounded by trees, three swans put in the mirror of the water, which returns the image of elephants. A work full of fantasy and humour.

Dali is also one of the best painters of the last century who took an interest in mathematics, welcoming Tom Banchoff (1938-) then René Thom (1923-2002) into his home. His work bears the obvious trace of these encounters.

10. Sicilian tilings

The impressive gallery of photos we just saw gives a fairly good account of the three characteristics that have just been mentioned. These are fascinating floor tiles present in the Palatine Chapel in Palermo and in the nearby cathedral of Monreale. They are all different and original, unique in themselves, therefore singular, attractive, arousing curiosity like any unusual work, arousing interest that testifies to an authentic relevance, perhaps hidden, to be specified.

5. *Fifth common point: the universality of works.*

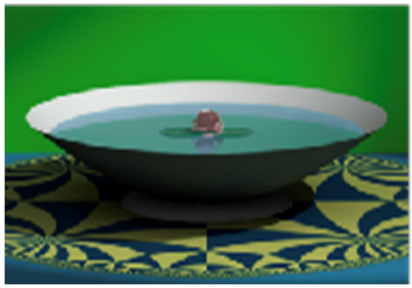
Universality is conceived both in space and through time. This is an extreme form of spatio-temporal stability.

Great artistic works, insofar as men and the elements do not destroy them, possess this property of temporal stability. We still admire the prehistoric engravings present in the caves and caverns, or the offering scene which adorns the tomb of Ramses II, and dates from around 3000 years ago.

11. Chauvet Cave (-30 000)

12.The Offering of Ramses to the god Ptah-Sokar-Osiris and to the goddess Isis

The vase resting on the doily, both associated with so-called hyperbolic geometry, was commissioned from Jos Leys. It in no way claims to have the artistic value of previous works: it is there to illustrate, symbolize the presence and durability of mathematics.



13. Hyperbolic vase placed on a hyperbolic doily Bruter-Leys

Mathematical works, that is to say the statements that constitute the corpus of mathematics, again have another advantage over works of another inspiration. Certainly, if the Mona Lisa were exhibited on Mars, all the Martians would not fail to come running to admire it. But it would still be necessary to be able to move this masterpiece without difficulty to our distant neighbour. Its universality is more temporal than spatial. And it will also be noted that the universality of works of art other than mathematics is only relative, because humanity and all its works can disappear following any cataclysm. On the other hand, the theorems of mathematics are true throughout the universe, and do not fade with time. These are timeless, unchanging truths at the centre of the earth, inside the sun, and even deep within black holes.

6. *A final point common* to most if not all of the arts is the role played by the *presence of wave phenomena, and the infinite multiplicity of their frequencies.*

With regard to the visual arts and mathematical art in particular, we can never insist enough on the role of this major wave phenomenon, the marvellous one of light, even though it seems obvious to us. Light, the world of photons, first plays an essential constitutive role in our reachable universe, which goes from the physical to the living. In terms of the figurative arts, light lets us see the shape of objects, ensures their relief, underlines the characteristic and revealing nuances of their constitution. It gives the fundamental elements of their representation.

To evoke his role in this medium of the arts, this touching work:

14. George de La Tour. Saint Anne with the Child Jesus, circa 1645-1650.

What future for her silently sleeping child does this soft and luminous face of an attentive mother dream of in an expressive half-light?

Light is first and foremost for us the sun, creator of the shadows of objects on the ground. It projects the outlines, it defines the forms.

Was Archimedes drawing in the sand when he lost his life? Sumerians, Egyptians, Pythagoreans, did they teach in front of their disciples using a blackboard? Couldn't the myth of the cave have been suggested to Plato by the way he taught geometry?

It is therefore not too adventurous to think of the first plane geometry as the study on the plane of the ground of the shadows of objects illuminated by the sun. Let us also remember that the origin of perspective, of projective geometry comes from the conception of the Ancients, still shared by many scholars in the 17th century, imagining kinds of light rays which left the eye to reach the objects actually seen.

The statement that founds the Euclidean geometry of the plane is an observation of geometrical optics between the object and its shadow. It bears the famous name of “theorem” of Thales.