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Social, economic, and functional influences play a vital part in all human activities, from the sciences to the arts. But there are other factors which also have to be taken into account—our feelings and emotions. These factors are often dismissed as trivial, but actually their effect upon men's actions is immense. A good share of the misfortunes of the past century came out of its belief that industry and techniques had only a functional import, with no emotional content. The arts were exiled to an isolated realm of their own, completely insulated from everyday realities. As a result, life lost unity and balance; science and industry made steady advances, but in the now detached realm of feeling there was nothing but a vacillation from one extreme to the other.

Sigfried Giedion
1. Composition

Composition. The act of composing, or putting together a whole by combining parts.

1.1 From figuration to abstraction.

At the end of the XIXth century, a revolution started to take place in painting. Painters questioned that the images on the canvas were a mere projection of the an external and objective reality. Since Alberti, a painting had been a window through which to look at the world outside (Figure 1). The rejection of a strict division between object and subject, that is, between the objective reality and its representation, led painters to look for the ‘real’ meaning that lied behind the external appearance of natural forms.

Figure 1. Albrecht Durer. Drawing of a Woman.

This real meaning had to be expressed with means different to traditional perspective. In Cézanne’s Mont Sainte-Victoire (Figure 2) the natural elements are reduced to a system of marks and colors, and the perspective vision is replaced by a frontal disposition of layers (Rowe, Slutzky, 1963).
Theo van Doesburg experienced in his own work this transition from figurative to non-figurative representation. In Figure 3, the lines of the first composition reproduce the contour of the human figure. In the next studies the human figure is 'geometrized'. This process of abstraction culminates in the last painting, when the reference to the human figure has disappeared. At this moment, the link between the representation, the painting, and what is represented, the natural forms, has been broken. The painting becomes a composition of symbols; it is no longer the representation of an object but an object in itself.

The work of Mondrian takes this event to the limit. Once a system of symbols has been created, for example, one based on the orthogonal arrangement of lines and color planes, an infinite number of compositions can be created within the system (Figure 4, 4a). Compositions are the result of the combination of a limited number of elements (lines, color planes) according to certain operations (geometric transformations).
In Mondrian's compositions the meaning has to be found in the compositions themselves rather than in the objective world. The meaning that is attributed to each composition is a matter or subjectivity: it is the artist himself, or the public, who assign their own meaning to the forms they see on the painting. In this situation, the task of the painter is to translate a particular emotion or vision by means of a formal system made up of simple elements, as lines and planes.

1.2 A new concept of space.

Abstract painting is not limited to the reduction of natural form to geometric figures. A new vision of space is contained in the work of the cubist painters, as Picasso and Braque (Figure 5). The traditional representation of space in perspective view, that had dominated painting since the Renaissance, was abandoned. Braque, for example, considered necessary to draw simultaneously three or more figures to portray every physical aspect of a woman; "just as a building needs to be drawn in plan, elevation and section".

Space became fragmented in multiple views which were overlapped and reassembled. Through the overlapping of the different surfaces a new concept of space emerged. The perception of depth in a cubist painting was different to the one based on the use of perspective. The viewer, being confronted to a cubist painting, would find that multiple interpretations were possible according to the different relationships between the different planes of the picture (Rowe, Slutzky 1963). This way, a dialogue between the picture and the viewer is achieved: the link that the painting is establishing is not between the real world and the picture plane but between the painting and the viewer.
The multiple overlapping of views on the same picture was related to the concept of space-time by the poet Apollinaire. In a rather metaphoric way, the multiplicity of views of the same object was related to the idea of space-time and the theory of relativity in physics. Thus, a new dimension, time, was introduced in painting.

Cubism had a decisive influence on the work of other artistic movements, as for example the Dutch group De Stijl. In the work of De Stijl, however, the concept of space was different to the cubist one. In the compositions of Mondrian and some of Van Doesburg, space is not represented by the overlapping of figures. Space exists independently from the figures themselves. It is a two-dimensional, infinite space where shapes, abstract symbols are arranged.

The Composition XIII by van Doesburg (Figure 6) is made of line segments arranged in the horizontal and vertical directions. Those segments lie on a boundless (if we forget the physical limits of the frame) two dimensional space. The subject matter of the painting is not so much the composition of lines over a plane as space itself. To prove that, the areas defined by the intersecting lines are colored.

Figure 6. Theo Van Doesburg. Composition XIII, Variation, 1918

1.3 The underlying arithmetic principles of compositions.

Some of Van Doesburg's early designs are close to Mondrian's experimentation within a well-defined formal system. In the design for the pavement of the ground floor of De Vonk house, Van Doesburg used as a module a composition he had made before (Figure 7).

Figure 7. Theo Van Doesburg. Composition, 1917

The basic module is repeated and rotated along an axis passing through the center of the square to make up the whole pattern of the entrance. Other transformations are used in the rest of the ground floor area, based on the same module. These transformations are the isometric transformations of rotation, reflection and translation, as well color substitution (Figure 8).
Figure 8. Theo van Doesburg. Original design for tiling, ground floor, De Vonk, 1918.

A design made in this way goes beyond the scope of a particular case. What Van Doesburg is creating is a complete formal system which has the potential to generate an infinite number of compositions. This formal system is based on a limited number of elements and a set of operations. The elements are color rectangles and the operations are the isometric transformations.

An artist, in this case, cannot operate only by intuition. The artist is carrying out two tasks simultaneously: first the intuitive creation of the forms and the rules that control them; and second, the systematic application of those rules (created by him) to control the design. In other words, an artist working in this fashion is using both his intuition and his capability for systematization.

A composition made according to these principles becomes the expression of some underlying mathematical principles. For that reason, the most relevant aspect of Van Doesburg design for the pavement is not the composition itself but the procedures that are used to create it. The composition, that is, the lines and color surfaces, is only the graphic expression of some underlying mathematical principles that lie behind the forms.

1.4 The aesthetics of computers.

Some of the aesthetic principles that are present in the work of De Stijl and, especially in the work of Van Doesburg, can be brought into the realm of computers. Other designs for the pavement of the De Vonk house, for example, could be executed mechanically after the procedures for the creation have been made explicit. To create another composition, based on the same principles as the original one, is a matter of computation of certain shapes (color rectangles) according to well established rules (reflection, rotation). Art understood in this way becomes a sort of 'permutational art', - *exploration systématique d'un champ des possibles* (Moles 1971)-, and can be the result of computation of an algorithm by a computer.

The parallelism between the aesthetic principles that are present in the early work of De Stijl and the characteristics of a computer tool is not a matter of casuality. Computers also deal with abstract symbols, as much as a De Stijl composition does. It is precisely the underlying mathematical structure of the composition what a computer can control, and not the formal appearance of it (that remains exclusive of the human mind). Its is by acting on that mathematical structure that new designs can be the result of computation.

Other sort of similarities arise from the fact that both, an the Stijl artist and a computer, use geometric elements as elements of composition and have a similar conception of space. The representation of an object in the computer is based on the
- application of the principles of analytical geometry. An object can be represented as a set of points; lines are the result of connecting the points; then a set of lines define a surface and different surfaces define a volume. All of these geometric elements are defined in a Cartesian space and the transformations that can be applied to them are the result of the computation of a system of simultaneous equations by the computer.

Evidently, this parallelism is not due to the existence of an aesthetic that is embedded in the computer. This is precisely what computers themselves cannot provide: an aesthetic which results from their application. Because of this, to put together certain aesthetics principles (De Stijl) and a tool that support those principles (a computer modelling system) seems to be a logical step to take. At this point, it can be argued that if computers would have existed in the time of De Stijl, then much of the work of painters, sculptors and architects would have been conceived and represented using computers.

References.

2. Construction

Construction. The act or process of constructing. A three-dimensional work of art, usually nonrepresentational and constructed of more than one material.

2.1 From the plane to space: Cubism and Constructivism.

The new forms of representation that were being explored by painters started to blur the boundaries between representation and reality. The collages of Picasso, or the objects trouvès from Duchamp, were no longer representations of an objective reality but they were part of that reality (Figure 9). Reality was brought into the realm of representation. Thus, the relationship between representation and reality started to be reversed, or in Ozenfant's words: "The emotion no longer comes from an extrinsic object reproduced or painted in the canvas, but within the picture, the tableau-object".

Figure 9. P. Picasso. The Guitar, 1913.

Figure 10. V. Tatlin. The Bottle, 1913.
The change of roles between reality and representation initiated by Cubism, was further developed by Russian Constructivism. Under the influence of cubist collages, Tatlin created in 1913 his first non-utilitarian constructions. His first composition, named The Bottle, is still a collage in cubist terms (Figure 10). However, he moved later from collage towards what he called painterly relief. In the composition Selection of materials (Figure 11) the objects project out of the picture into the real world. In the Corner Counter-relief (Figure 12) a new step is taken towards the separation from the surface of the canvas. The objects are now attached to two different planes: the two walls of a room that intersect at the corner.

The work of Rodchenko followed a similar evolution from abstraction to reality. He detached the objects from the two-dimensional plane and worked with three-dimensional constructions fully in space. His sculptures are the result of a process of abstraction similar to the one taken earlier in painting. These sculptures are also non-figurative; they are made up of the combination of simple geometric elements.

His first Non-objective sculptures still lie in a gravitational space: the verticality of the object is cancelled out by the horizontal platform that keeps the different parts in balance (Figure 13). There is, however, some contradiction between the immateriality of the object, built with thin plates as if they were only geometric planes, and the distribution of the forms that responds to the forces of gravity.

This contradiction disappears in the three-dimensional objects suspended on space, the so-called Spatial construction/ Spatial object (Figure 14). The horizontal-vertical relationship is no longer necessary when the object is 'floating' in space (in fact, the object is not really floating but suspended by a wire from the ceiling). As a result of the detachment from the ground, the objects become spheres, with their infinite number axes being projected in the whole three-dimensional space. This way, the shape of the object acknowledges that space is no longer restricted to a horizontal plane plus the vertical dimensional. Space becomes fully three-dimensional. Also, the suspended objects are continuously changing their positions. Thus, it is not only the viewer who can adopt multiple positions to contemplate the object. The object itself is also changing its position continuously.
2.2 The meaning of the 'Composition vs. Construction' debate.

The distinction between two dimensional compositions and three dimensional constructions, which is one of the major issues in the work of Tatlin and Rodchenko, became the key issue in the formation of the Constructivism theories in the early twenties. Rodchenko played an important role in the adoption of the term 'construction' as the expression of the new aesthetic and he can be considered as the founder of Constructivist theory (Lodder 1983). For the members of the First Working Group of Constructivists, the founding group of Constructivism, "construction is the system by which an object is realized from the utilization of material together with a predetermined purpose".

It is necessary to recall, however, that the debate about composition and construction, that was at the origin of Constructivism, was something more than a discussion about two different kinds of formal representations. The real purpose of the discussion was about the role of the artist in a new revolutionary society. Russian Constructivist artists wanted to contribute to the creation of the new society in an active way. The artist task was, therefore, to create real objects for which no reference could be found in the real world (Lodder 1983). By favouring construction over composition, they denied the validity of the existing reality. There was nothing in that reality that was worth to be represented on paintings; the real task of the artist was to construct objects, to build the new world.

2.3 From space to the plane: Lissitzky.

The work of Lissitzky reflects an opposite direction with regard to the one taken by Tatlin and Rodchenko. In the work of those artists the objects represented in the paintings ended up entering the realm of materiality. The Painterly reliefs of Tatlin or the Non-objective sculptures from Rodchenko do not represent an object, rather, they 'are' the object.

For Lissitzky, on the other hand, the pictures are the representation of some three-dimensional object. However, the object that is represented in the painting does no exist in reality. The only sign of existence is the picture itself. Whereas the 'painterly relief' from Tatlin leaves the canvas to enter the universe of material objects, the compositions of Lissitzky are projections of an imaginary three-dimensional world (Figure 15).
In the work of Lissitzky, the relationship that exists between the idea of an object and its representation is similar to the one from Cubism. Lissitzky is an architect who has entered in the cubist space, and is able to conceive and represent an idea within that universe (Figure 16). His paintings were the expression of an architectural idea, so that painting and architecture were blended in a very unique way. In his work, painting, sculpture or architecture became one and the same thing. Because of this, he coined the term PROUN, (acronym that stands for ‘Project for the affirmation of the new’), to describe ‘every organized piece of work-whether it be a house, a poem, a painting was a practical object’.

2.4 An object in space: Rietveld’s Red and Blue chair.

The work of Rietveld did not go through the evolution from the canvas to the space as the one from Tatlin or Rodchenko. Trained as a carpenter, his pieces of furniture are made assembling simple forms directly in space. His Red and Blue Chair, of 1918, was quickly adopted as a symbol of De Stijl group (Figure 17). It shares with many other artistic productions of that time the willingness to decompose an object into its most elemental parts. These parts are just the materialization of the same geometric elements (lines and planes) that Van Doesburg and Mondrian were using in painting.
A relevant aspect of the chair is the tension established between the whole and the parts. On the one hand, the parts are assembled in a way that each one maintains its identity and so that each is immediately comprehended in its spatial and functional relationship to the others (Brown 1958). The identity of the parts is preserved by avoiding that the stanchions (horizontal wooden members) and rails (wooden posts) intersect at a single point. Those members extend beyond their intersection point, as if they had an infinite length, which could extend into the infinite space. The thin wood plates, that make the back of the seat of the chair, are also independent pieces.

In spite of the willingness to preserve the individuality of every single component, the design succeeds in transmitting the idea of wholeness. The chair is more than the sum of parts. To appear as a form, according to the principles of the Gestalt, a group of elements need to be perceived not as an accidental arrangement of parts but organized according to intentional rules (Moles 1971). The success of this design lies in the balance that is achieved between two opposites: the separateness of the elements and the uniqueness of the whole figure.

The separate parts are grouped together by means of color. The stanchions and rails that make the frame, for example, are painted in black to acknowledge that all of them together make a functional component of the chair: the frame that supports the back and seat. The back and the seat, unlike the components of the frame, are unique elements. Neither of both is repeated, as the wood segments of the frame are. Each of them is a group made out of one element and, therefore, each one is distinguished with its own color: red for the back and blue for the seat.

Where a two dimensional plane cuts the wooden members of the frame, a yellow color distinguishes the resulting surface. According to the logic behind the application of color, every group of elements is distinguished with its own color (back=RED, seat=BLUE and frame=BLACK). The set of surfaces at the edges of the stanchions are considered a separate group and, for that reason, they are painted in yellow.

The importance of this design lies in its spatial concept. For both Van Doesburg and Rietveld, space is an a priori element. In much the same way as the lines in the compositions of Van Doesburg or Mondrian connect the grid intersections of a two dimensional Cartesian space, the stanchions and rails of the frame of the Red and Blue chair simply connect the grid intersections of an infinite three-dimensional space. To reinforce this idea, the back and the seat appear as if they were floating in that space, suspended over the black frame.

Therefore, it is the materialization of space what the chair is all about. Because of this, it can be taken as an architectural experiment. In fact, it is not by chance that the design for the Schröder House, made later by Rietveld, follows some of the ideas developed in the chair. (see Chapter 3, Space, for a discussion on this house)
The search of the fundamental elements is one of the basic principles of the artistic movements of the beginning of this century. In all the artistic disciplines, those fundamental elements were to be found in the realm of geometry. The point, line and plane were the smallest units an artist could use in painting, sculpture or architecture.

The most relevant aspect, however, is the key role played by geometric elements in the formal expression of the works of that period. In every discipline, the geometric elements became 'materialized' so that they had a direct visual impact in the work itself. Geometry was no longer the underlying/invisible structure of form, as it had been in the past. In the work of the avant-garde, Geometry was made visible, it became a formal language.

These two aspects involved with the search of the fundamentals, that is to say, the decomposition of form in the smallest units and the 'formalization' of Geometry, can be perceived in the three-dimensional objects built by the Russian constructivists. The objects built by Vladimir Stenberg are the materialization of a three-dimensional diagram built with lines. In the *Construction for a Spatial Structure no. 6* (Figure 18), three different set of lines can be identified:

- the longer and thicker ones that make up the pedestal,
- the shorter ones in the upper part,
- and the wires that stiffen the lower part.

![Construction for a Spatial Structure no. 6](image)

Figure 18. V. Stenberg. Construction for a Spatial Structure no. 6.

Unlike the space in the canvas, the physical space, where this construction stands, is gravitational. The forces have to be transmitted through the members of the object to the ground. In this regard, this object has to behave as one of the frame structures used in bridges and buildings. In fact, according to Stenberg, these constructions were conceived as explorations towards the realization of actual buildings (Lodder 1983).

The work of Gustav Klutsis is also characterized by the use of frame structures. In his work, lines are grouped to create elemental figures such as cubes. In his *Three-dimensional Construction* the prism, more than the line, seems to be the unit of the composition. Precisely, the prisms are scaled and located inside each other, in a rather systematic way. (Figure 19)
In the Design for a Screen-Tribune-kiosk (Figure 20) the figure of the cube can also be recognized. There is also a clear characterization of the different parts that make up the kiosk: the framed cube at the base, a smaller cube on top of it, the cruciform elements on the sides, the planar surface on the top. Each of these parts also have a specific function: stand for political speaker, screen for the display of news-reels, book-stand for the display of literature and a board for posters.

2.6 Abstraction and reality in the computer.

The discussion about reality and representation, which was present in the work of Russian constructivists, can find some parallelism in the current computer modelling systems. As in the compositions of Lissitzky, objects modelled with a computer system do not exist in reality. The only sign of existence is the two-dimensional projection on the screen.

The three-dimensional model of an object built on the computer is projected onto the screen by means of perspective transformations. Every time that the object changes its position in space, a new perspective is generated and displayed onto the two-dimensional screen. This creates the illusion in the user of a computer modelling system that he is working in a real three-dimensional space with real three-dimensional objects.

Thus, in the computer allows to generate a multiplicity of tangible two-dimensional projections from a physically non-existing three-dimensional. This is also the case with Lissitzky's compositions. The images on his paintings seem to have its source in a three-dimensional object, or in other words, the composition in the painting is the result of different projections of that object onto a plane. Incidentally, this can be considered as a genuine architectural thinking process. While the painter has to give an answer to the issue of the link between representation and reality, the architect does not have to face the same problem. What the architects represents is something for which, in principle, there is no previous reality.

The representation of space in a computer could also fulfill some of the goals of some Constructivist artists. In the work of Rodchenko, for example, there is the intention to liberate the object from the forces of gravity. In the physical world, he could just simulate that effect with the floating objects, although they still needed to be hang from the ceiling through a wire.

The non-gravitational space that Rodchenko would have needed exists in a computer. When an object is created in the abstract space of a computer, it is possible to dismiss the force of gravity. As a result, the form of the objects does not have to accommodate to the requests of gravity forces. Thus, in the same way that the shapes of the Spatial Objects go from vertical to spherical, following the evolution from the ground to the space, similar constraints that determined the
shape of objects can be questioned in the abstract space of the computer. In a computer modelling system, an object is built only with geometric abstractions (lines, surfaces, solids). Then, some materials or textures can be added to the geometric elements as attributes. With a rendering program, realistic images of the object can be created. In spite of their realistic appearance, the process to create the 'realistic' object in the computer has no parallel with Constructivist objects. For a constructivist artist, the materiality of the object, its physical properties, determined the characteristics of the construction. In the computer, on the other hand, objects are created not with physical components but with the geometric abstractions.

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3. Space

Space. The continuous expanse extending in all directions or in three-dimensions, within which all things exist, variously thought of as boundless or indeterminately finite. The distance, expanse, or area between, over, within, etc.

3.1 The search of a new aesthetic.

The revolution that took place in the arts at the beginning of the century affected all disciplines. A common goal was being pursued in painting, sculpture and architecture: the creation of a new aesthetic to break with the past. The rejection of tradition brought out the necessity to find the fundamentals in each discipline. It was necessary to start again from the beginning, that is, to define the basic elements, in order to build up a complete new aesthetic.

In all artistic disciplines, the basic elements were to be found in the domain of geometry. The elements of Euclidean geometry -the point, the line and the plane- were the smallest units the architect or the painter could work with. It was precisely the need to define the basic elements what helped to create a formal language which was equally valid for all disciplines. Precisely, both the modern painter and the modern architect worked with the same basic geometric elements: lines, planes, solids.

Although the search of a new aesthetic was initiated by painters, painting alone was not the only source of new concepts in art. There was an active interaction between different disciplines. Painters found themselves addressing issues related to the representation of space, while architects composed their plans with abstract symbols in the same way as painters made compositions in the canvas.

3.2 Theo van Doesburg: a new concept of architectural space.

The work of Van Doesburg epitomizes the creation of a new territory common to all the arts. Although he started as a painter, he always was aware of the architectural implications of his compositions. In his work, the traditional boundaries that had kept architecture, painting and sculpture separated disappeared. A concept could be generated from any discipline and be transformed into the product of another. Van Doesburg, along with Lissitzky, are the best examples of this new approach towards artistic creation.

In his two-dimensional compositions, van Doesburg already acknowledged the existence of space. In his early compositions, (see Chapter 1), space is not limited to the boundaries of the canvas. Rather, space is an infinite and two-dimensional entity which exists independently of the elements that are disposed on it (lines and planes). It seems then natural that Van Doesburg attempted the translation of the spatial concept of the compositions into architecture.
Van Doesburg’s first contact with architecture came as result of his collaborations with architects such as Oud or De Boer. In these works, his task was to apply color in the buildings designed by the architects, as in De Vonk house. The application of color surfaces was a way to dematerialize a building, to decompose it into a set of planes floating in three-dimensional space. Those planes were to become the spatial reference for the inhabitants of a building, even more than the enclosed space created by walls and slabs. However, the ultimate purpose of Van Doesburg was the transformation of the whole conception of architectural space.

The conception of space that van Doesburg had in mind could not be materialized in the first collaborations with architects. In fact, the actual outcome of their common work was that van Doesburg added color to the buildings, without affecting the way the buildings were conceived by the architects. Only after he started his collaboration with the architect Cornelis van Eesteren, could he really explore the architectural implications of the use of color and planes in three-dimensional space.

The projects that served for the investigation made by van Eesteren and van Doesburg were not actual houses, as the ones designed with Oud, but a project commissioned by the Parisian art dealer Leonce Rosenberg, a supporter of De Stijl and of the work of Van Doesburg. The first project, the Rosenberg house was mainly the independent work of Van Eesteren and the influence of Van Doesburg was again mainly in the addition of color. (Doig 1986) (Figure 21). The model reflects a building dominated by the compositions of volumes, following a kind of volumetric architecture that recalls some previous projects by Oud.

![Figure 21. Cornelis van Eesteren. Model of the Rosenberg House, 1922.](image)

The real effects of the collaboration between both, Van Eesteren and Van Doesburg, started to be noticeable in the next project for the ‘Private House’ (Figure 22). The axonometric drawings made for this project are the most clear illustration of the concept of space that van Doesburg was after. These drawings represent the architectural counterpart of the concepts developed in the early paintings (Figure 23). As in the paintings, space is the subject matter of this work. As much in the same way as in the paintings, the planes are arranged in a three-dimensional space, as if they were suspended on it. No volume is defined by the planes; there is the same strict separation between an existing space and the geometric elements that could be found in the two-dimensional compositions.
3.3 The destruction of the box: Wright and De Stijl.

The architecture of Frank Lloyd Wright played a strong influence in the original ideas of De Stijl. This influence came directly from the lectures of Berlage, and it was evident in the projects of Van't Hoff, who was in the original group of De Stijl. The first houses designed by Van't Hoff clearly resemble the ones from Wright. This influence became later less evident, in visual terms. However, some of the characteristics of Wright's architecture, like the contrast of vertical and horizontal, the pinwheel plan layouts and particularly, the idea of the destruction of the box, can be found in the work of Van Doesburg.

In the axonometric drawings of the Private House, one of the goals of the architecture of Wright, the destruction of the box, is expressed in a radical way. There are no limits between inside and outside spaces. There is also no reference to top or bottom, left or right. Also, there are no openings in those abstract planes. (Windows were another disturbing element that Wright wanted to eliminate from architecture). There are no perforations in the planes either, the only penetrations are the gaps that exist in between the planes.

It is precisely in the radicalness in the representation of the idea of the destruction of the box where lies the main difference with Wright. In the work of Wright there is no such a radical separation between the representation of an idea and its materialization. Wright built houses which materialized the idea of the destruction of the box by means of architectural resources: material, construction, light. He succeeded in creating new architectural concepts in an empirical way (Hoesli 1980), by building houses that were the expression of a new concept of space. From this point of view, the work of Van Doesburg and Van Eesteren for the Paris projects is a laboratory work, an experimentation with abstract forms.

The simplification of the formal language of architecture was the major contribution of the de Stijl and other European movements that started under the influence of Wright's work. The influence was then reversed, and went from European architects towards Wright. His Falling Water house is still an expression of the ideas that have been always present in his architecture: the vertical reference in the chimney, the extension of horizontal space, the tension between vertical and horizontal. However, the formal expression of the house, with the simple volumes and no added decoration, is the direct result of the new aesthetic that had been forged in Europe.

3.4 Volumes and planes.

Although the idea of the rejection of enclosed space is clearly expressed in the axonometric drawings, there are some contradictions with the image of the project offered by the model of the project for the Private House (Figure 22, 23). Looking at the model, the house recalls the former Rosenberg house done by Van Eesteren. Considering only the model, the project seems to have been designed with volumes rather than planes. Color is added to some faces of the volumes to emphasize the planar character, but this is again more a visual effect than a concept used in the generation of the design,
as it occurred in the previous collaborations between Oud and Van Doesburg. Moreover, in the model there is a clear separation of outside and inside space, which contradicts the spatial concept of Van Doesburg's compositions.

This double reading of the project, as a *composition of volumes* or as a *composition of planes*, raises some questions about the role of the axonometric drawings in the conception of the design. Some investigations about the contribution of Van Eesteren and Van Doesburg in the design seems to confirm the fact that the axonometric drawings were done by Van Doesburg tracing over the drawings of the finished house done by Van Eesteren (Doig 1986). If that was the case, the axonometric drawings should be considered as an analytical study made after the completion of the design. Thus, the question that was not solved in the project was how to conceive a building as a result of creating a space with separate planes rather than volumes (Figure 24). A solution to this question (a partial solution, though), was given by Mies van der Rohe.

![Figure 24. T. van Doesburg and C. van Eesteren. Elevations and axonometric drawing of the private house, 1923.](image)

### 3.5 Counter-constructions and Counter-composition.

After the axonometric drawings of the Private House, the fusion of architecture and painting appeared closer than ever. (Van Doesburg talked about 'painterly architecture'). Paintings would become the projection of three-dimensional planes, rather than compositions of lines on the two-dimensional surface. Every change in the viewpoint would create a different composition on the canvas. Van Doesburg coined the term *counter-construction* to refer to this new kind of work in which painting and architecture became one and the same thing.

The *counter-constructions* were then projections of planes from three-dimensional space onto the picture plane, in much the same way as the axonometric drawings of the private house (Figure 25). Initially, the counter-constructions referred both to architecture and painting. Later on, Van Doesburg distinguished between *counter-compositions*, referring to painting, and *counter-constructions*, which were specific of architecture. These new compositions represent the transition from Neo-plasticism, characterized by the right angle compositions of Mondrian, towards Elementary (Baljeu 1974).
3.6 From experimentation to practice: Mies van der Rohe.

Van Doesburg’s investigations remained at the theoretical and experimental level. None of the three designs he made together with Van Eesteren was never realized. As he once said, the results of those investigations would be put into practice by others. This was actually the case with the research about the planes in space started in the project for the Private House. It was Mies van der Rohe the one who provided a practical answer to the use of planes in the conception of a building.

Mies was for a short time a member De Stijl, before becoming a founder of the G group in Germany. He was familiar with the work and ideas of van Doesburg (as almost everybody else in Europe). The comparison between one of the first compositions of Van Doesburg, *Rhythms of a Russian Dance* (Figure 26), and the project of Mies for a *Brick Country House* (Figure 27), shows clearly that the painting provided the original concept for the house. Mies captured the architectural idea that existed in Van Doesburg’s composition, that is, its spatial concept, and transformed it into a project.
Unlike Van Doesburg, Mies did use planes in the conception of the design. However, Mies did not solve completely the problem that van Doesburg was posing with his axonometric drawings. The space where Mies places the planes is not fully three-dimensional; rather, it is a space composed of a horizontal plane, where the planes lie, plus a vertical dimension, which is the direction of extrusion of the planes. In the axonometric drawings of Van Doesburg, on the other hand, the planes lie in a full three-dimensional space. What Mies did not address, therefore, was the interpenetration of space in all three-dimensions.

This limitation to one horizontal level is also perceivable in other projects by Mies developed from the same concept. In the Barcelona Pavilion, the horizontal plane is materialized in the podium where all the vertical planes stand (Figure 28). The pavilion succeeds in eliminating the barriers between outside and inside: a visitor can flow through the space from inside to outside without interruption. However, even though space flows quite naturally over the horizontal plane, it is interrupted vertically by the flat roof in a dramatic way.

![Figure 28. Mies van der Rohe. The Barcelona Pavilion, 1929.](image)

### 3.7 From experimentation to practice: Rietveld’s Schröder House.

If Mies took the spatial concept from a painting and transformed it into a building, Rietveld did a similar thing with an object: he translated the spatial concept of his Red and Blue Chair into the Schröder House. A possible reading to make is that both the painting and the chair served as architectural experiments at a small scale. Then, the spatial concepts discovered in those investigations were translated into architecture. (However, the possibility of an opposite reading is also feasible; that the chair and the painting were generated from the architectural realm.)

In Rietveld’s case, however, the transition from experiment to practice is less clear than in Mies case. Some similarities between the chair and the house are obvious, particularly, the way in which the slabs, posts and beams are connected in the facade: they extend beyond the point of intersection in much the same way as the rails and stanchions in the chair do (Figure 29). But, while the chair acknowledges the existence of a three-dimensional Cartesian space (connecting points of that space with linear wooden members) the house does not do so.
Unlike the chair, the house fails to materialize a concept of a space. The decomposition in planes only has an influence in the envelope of the house (Figure 30); it does no affect to the totality of the design. In spite of the decomposition in planes, the facades create a barrier between the inside and outside. Therefore, the interior of the house responds to the traditional concept of a well-defined volume rather than to the more innovative interpenetration of spaces in all directions, as suggested in van Doesburg’s axonometric drawings.

Even though a three-dimensional object can serve to experiment with architectural ideas, the translation into architecture is not always a direct one. Two features of the facade of the Schröder house can illustrate the limits of the method: the supports for the balconies and the frontal plane anchored in the slab of the balcony, above the entrance.

As it has been mentioned, the beams and posts that support the slabs of the balcony are joined in much the same way as the stanchions and rails in the chair. In the chair, it is straightforward to connect the wooden pieces in such a way. The same kind of intersection applied to steel posts and beams is equally valid in the house, from a construction stand-point (Figure 31). However, the front plane that appears to be suspended in front of the main balcony does not reflect the same honesty in the use of materials. The fact that a piece of wall floats in space challenges the basic principles of physics. What is actually happening is that some supports coming out of the facade serve as a support for the wall.
3.8 Space in the computer.

In the computer, space is represented as a three-dimensional Cartesian grid. Any object is built and placed with regard to a coordinate system. Before an object is modelled, space (the mathematical expression of space) already exists in the computer. This represents, in fact, a similar concept of space as the one Wright, Van Doesburg or Mies were working with.

The existence of the three-dimensional grid can be made evident in the objects that are built on that space. The Red and Blue Chair, for instance, is an example of an object built according to the constraints imposed by the existence of a three-dimensional space. Similarly, objects built in the computer can reflect in the same way that they have been built in a space that existed before the object itself.

It is necessary to be aware, however, that with the standard modelling systems, the only actual space that can be perceived in the computer is the two-dimensional surface of the screen. It is because of the coordinate system that a communication can be established between the mind and the computer. This way, a three-dimensional model can be built working only with two-dimensional projections on the screen.

As in the counter-constructions of Van Doesburg, the two-dimensional drawings that appear on the screen of the computer are the projection of a three-dimensional model. Every change in the position of the viewpoint will create a different counter-composition in the surface of the screen. Also, in the same way as in the counter-composition, surfaces can be transparent when they are projected from a wireframe model.

In the physical world, space is perceived as the void that exists between the objects (Arnheim 1977). By moving through a space an individual receives continuous impressions of separate aspects of the physical surrounding and with them creates an abstract image in his mind. In the computer, it is possible to approximate such a perception of space with animation. Once an object has been modelled, the continuous sequence of projections onto the screen can give the impression of a walk-through. With more sophisticated equipment, the limitation of the projection on the screen can be overcome. A virtual three-dimensional space can then be created, and then the user can be inside the space itself, rather than seeing a succession of images projected onto the screen.
References.


4. Object

Object, a thing that can be seen or touched; material thing that occupies space.
Mass, a quantity of matter forming a body of indefinite shape and size.
Solid, tending to keep its form rather than to flow or spread out like a liquid or gas. Filled with matter throughout; not hollow.
Volume, the amount of space occupied in three-dimensions.

4.1 Space and Volume.

It can be contended that, traditionally, architects conceived space as contained within the limits of a box. According to this conception, space is the outcome of a form: it is determined by the boundaries of geometric elements. The work of Wright, particularly the series of Prairie Houses, marked the beginning of a path towards a new concept of architectural space based on the 'destruction of the box.' For Wright space was no longer the consequence of form; rather, space was thought as an autonomous entity, independent from the container itself.

The work of Van Doesburg and Mies can be considered as a continuation of the exploration initiated by Wright. In the projects of Van Eesteren and Van Doesburg and in the Brick House of Mies, space does exist a priori while the forms, represented by planes, only lie on it. By reducing form to the minimal expression (simple geometric planes), these projects emphasize space over form in a more radical way that Wright did. Altogether, though, Wright's Prairie houses, the Private House of Van Eesteren and Van Doesburg and Mies Barcelona Pavilion can be considered as different episodes in the path towards the autonomy of architectural space from form.

These two conceptions of space, one as contained within a form and the other as unbounded and separate entity, have been addressed by Eisenman in terms of the difference between 'volume' and 'space'. According to Eisenman, space can be considered 'as the continuous, unbounded condition' and volume as 'particularized, defined and contained space'. (Eisenman 1963).

4.2 Mass and interior space.

One of the results of focusing on space rather than form, was that architects favoured interior space over the exterior expression of the building. As a result, the exterior was just the direct outcome of the interior. This is particularly evident in the projects of Mies for the Brick House or in the Barcelona Pavilion. Neither of the two projects can be assimilated to a cube or a box, or any other geometric solid. The external boundaries of those two projects are the outcome of the free disposition of planes (solids), which in turn is determined in terms of space definition. This new way to understand
a building broke radically with some architectural tradition according to which outside and inside were equally important in a building.

In the studies of Leonardo for buildings with centralized plan, for example, the external configuration is defined by means of simple geometric solids such as cubes or spheres (Figure 32). Thus, starting from the external definition of the building (the volumetric abstraction), the interior space, depicted through the plan, is determined. Similarly, the project of Bramante for San Pietro in Montorio is also the expression of an architecture which is conceived both from the outside and the inside. (Figure 33)

The understanding of interior space as being carved out from a solid mass was typical in most of the Renaissance buildings. In Michelangelo’s project for Saint Peter, for example, the interior space seems to have been carved out from the mass of the building as much in the same way as a sculpture is made by “cutting away from the block”. Bruno Zevi’s interpretation of the plan, (the positive-negative drawing of the plan) illustrates the concept of space that lies behind the project. (Figure 34)
The void created inside a mass does not necessarily have to be inert, that is, with no properties of its own. In the Baroque, space became 'activated' and acquired some dynamic properties. In San Carlo alle Quattro Fontane, for example, it is the inner space that exerts pressure on the walls, thus expanding them towards the outside (Figure 35). In this case, the interior space cannot be understood simply as a by-product of a subtraction operation. Space, in this case, has properties of its own, manifested in the forces that deform the walls of the container.

Figure 35. Borromini. San Carlo alle Quattro Fontane, Roma.

The conception of interior space as a void within a mass is, by no means, exclusive of the Renaissance or Baroque periods. Even architects who were close in time to the Modern Movement, like Berlage, conceived space as a void. The central space of the Stock Exchange can be thought of as being carved out from the solid brick mass that makes the building. (Figure 36)

Figure 36. Berlage. The Stock Exchange, Amsterdam, 1898.

4.3 Solids as formal language.

A significant step in architecture was taken when solids (cubes, spheres, cones, cylinders) became the expression of the building rather than the underlying abstract framework supporting the architectural form. In the sketches of Leonardo or in San Pietro in Montorio, even though the elemental figures can be easily recognized, the formal expression comes from the use of the classic formal vocabulary (column, capital, entablature).

In the ideal designs of Boulée and Ledoux, solids themselves made out the formal vocabulary (Figure 37, 37a). However, in spite of the revolutionary step taken by these architects, the architecture of XIXth century ignored the use of pure forms. It was not until the XXth century when architects considered again the possibility to employ a formal vocabulary made out with simple solids.
Some of Oud's early designs, could be understood from the outside as pure boxes. The housing project in Scheveningen, designed by Oud in 1917, is an aggregation of rectangular boxes, each one corresponding to a housing unit (Figure 38). The volume, in this case, is the element of composition. Compared to the Renaissance buildings, this example of early modern architecture gave the impression that all external decoration had been removed, having a pure solid as a result.

However, for the Modern Movement, solids were more than just the result of the elimination of the decoration from the surface. For Le Corbusier solids/volumes were the essence of architecture: "L'Architecture est le jeu savant, correct et magnifique des volumes assemblés sous la lumière." (Le Corbusier, 1923). Thus, the use of a formal vocabulary based on simple solids became a fundamental principle of the Modern Movement. As Reyner Banham points out, "it might be taken as a general characteristic of the progressive architecture of the twentieth century that was conceived in terms of a separate and defined volume for each separate and defined function, and composed in such a way that this separation and definition was made plain." (Banham 1960)

Projects like the Bauhaus building by Gropius, for example, confirm Banham’s assertion. In the Bauhaus, every function has a different volumetric expression: the dormitory is in the small and compact volume; the workshop in the long volume that runs parallel to the main access road (Figure 39). In spite of being conceived as separate volumes (solids) with different functions, all of them are connected as to create a continuous figure that can be read in plan view as complete in itself. Incidentally, each volume becomes a distinctive part not only because the dimensions of the solid itself but mainly due to the different treatment of the surfaces in each case. The dormitory, for example, is perforated with punched windows while the long facade of the workshop is glazed from top to bottom with a steel and glass.
Similar approaches (identifying solids with functions) can also be found in more recent work. In the project for the Hotel Berlin, by O.M. Ungers, prisms and cylinder are the basic formal elements (Figure 40). Each one of them represents a component of the building: the 'glasshaus', the 'mauerhaus', the 'aufzugstürme' and the 'rotunde'. Solids in this case, are used as pure abstractions lacking physical mass: there is no intention to explore the plastic nature of solids in the expression of architecture. In this project, solids are three-dimensional symbols representing every part of the building. In spite of the strict separation of parts, the unity of the project is guaranteed using a Cartesian geometric structure which is underlying the design.

The work of Frank Gehry, on the other hand, focuses on the exploration of the plastic possibilities of solids to create architectural form. In the project for the Vitra Museum, different masses seem to have clashed freely in space, as if the building had been just the result of an accident (Figure 41). Solids have abandoned the arrangement in the orthogonal three-dimensional grid and are placed at any orientation.
4.4 Volumes and exterior space.

Two seems to be the consequences of conceiving architecture in terms of solids: first, the interior space is the result of the subtraction of some mass; and second, the exterior definition of the building comes first in the design. In fact, the most direct consequence of using solids is that the exterior space is created as the negative of the object itself. Whereas it is very intuitive to use a solid to represent a complete building or a part of it, it is not so common to find interior spaces that have been conceived as a result of the disposition of three-dimensional objects in space.

The architecture of Mies clearly illustrates this point. In the Barcelona Pavilion, interior space (if one can talk about interior and exterior in this building) is defined by the arrangement of different solids (which are a more accurate abstraction of the ideal planes, if we consider the built project). Thus, by identifying solids to a component of the building (walls), rather to the whole building, a different concept of space was created. (Figure 42)

In the project for the Illinois Institute of Technology, on the other hand, each building can be read as a solid. The different solids are arranged over the rectangular area of the campus in a way that recalls the arrangement of walls in the Barcelona Pavilion. As a result of this arrangement of solids, a space is defined; in this case is the space in between the different buildings. Therefore, a similar mechanism lies behind the two projects. In each one, the arrangement of solids results in the creation of space. When solids are walls, as in the Pavilion, the space that results is an interior space. When solids are buildings, as in the IIT, an exterior space is created. (Figure 43)

The identification of the whole building with one solid has as a result the creation of exterior space. Le Corbusier was aware of this fact when he designed the project for the League of Nations competition. The whole project can be read in plan in terms of figure-ground: the u-shape together with the linear bar, that make the secretariat, and the trapezoid that makes the assembly hall.
The axonometric drawing reveals that Le Corbusier was sensitive to exterior space that the volumes were creating (Figure 44). The figure-ground relationship in plan becomes a hollow-solid relationship in the axonometric. The vegetation that is drawn around the building can be read as the materialization of the hollowed space around the solids. In a more direct way, the existence of an space in connection with the solid buildings is also manifested through a secondary structure which is placed inside the space defined by the U-shape.

![Figure 44. Le Corbusier. League of Nations competition project, 1927.](image)

### 4.5 Objects as abstraction: a conceptual tool to design.

The necessity to conceive a building in terms of objects or complete figures can be attributed to the need an architect has to have a complete view of the building he is designing. As Arnheim writes "a building, like any other three-dimensional object, can never be seen in its entirety but only in projectively deformed aspects. This is true not only for the completed structure but also for its conception in the architect's mind, and since he cannot conceive his design without an integrated overview, he resorts to working with small models." (Arnheim 1977). Whether the architects uses models, or sketches, like the ones from Leonardo, the purpose of those abstractions is the same: to think of the design as a whole.

There are in this argument, two different worlds involved: one is the world of conception, where the architect acts to create a building; the other is the realm of perception, where an individual perceives and feels the spaces. It is assumed that the architect is aware of the differences between both universes, and when he uses models he uses them as an instrument to design and not as an end in itself.

However, the capability of architects to be aware of the boundaries of each world, conceptual and perceptual, can be objected. Very often, design decisions are taken within the realm of conception, fulfilling the requirements imposed by a specific formal representation (a plan, an elevation or a model). As a result, a model or an elevation view often become an end in themselves.

The early houses designed by Eisenman illustrate this. House I, II and so on, were conceived strictly within the realm of abstraction. In their conception, some of the facts that affect the perception of a real building seemed to have been ignored. As a result, there seems to be no much difference between a photograph of a model of one of the houses, and a photograph of the actual building. In fact, the building, even though is built, is still a model; a full-scale model. (Figure 45)
In Eisenman's architecture, the separation of the two realms, conceptual and perceptual, is stretched to the limit; to the extent that the link between the world of conception and perception does not exist any more. The design seems to be the manifestation of a purely intellectual activity. There is no place for issues that belong to the external world (material, light, cost, use). The expression 'Cardboard Architecture' (that he used to describe the work of the first four houses) gains, in this context, full meaning. His projects, the series of early houses, keep looking as models after they are built. They neglect human life inside or around them. As Eisenman himself acknowledges "The houses looked and were constructed like models. They were built of plywood, veneer, and paint, and were without the traditional details like mullions, flashings, and copings conventionally associated with an 'actual' house"(Eisenman 1987).

4.6 The limits of the volumetric abstraction in architecture.

The project of O.M. Ungers for the Messergebäude in Frankfurt is a good example of the limits of volumetric abstraction in architecture. In the exploded view of the building, the different components are shown as much in the same way as a machined part is depicted in engineering drawings (Figure 46). However, unlike the machined part, the actual building will not be built by assembling the parts that are shown in the drawing. The building will be built assembling the window frames, the stone panels, slabs and columns. Unlike the machined part, the assemble of elements that is shown in the drawing is more a conceptual tool than the exact description of the functioning of the different parts.
4.7 Object representation in the computer.

In the computer, three-dimensional objects are represented by means of formal abstractions made up with lines (wireframe modelling), surfaces (surface modelling) or solids (solid modelling). In the so-called general purpose modelling systems, objects are only geometric forms, lacking any architectural meaning.

Although this can be seen as an inconvenient, it fits well with the way most architects conceive a design. Usually, different meanings are assigned to the same form, depending on the context and the purpose of the design. A box, for example, can represent a wall or a building, indistinctively. Also, as in the projects by Ungers, three-dimensional objects in the computer can be used as a symbol for something else, for example, a function of the building.

A more powerful representation of objects is achieved in the computer with solid modelling. The objects thus modeled are not only lines and faces, they represent masses than can be added, subtracted or intersected. This way, complex forms can be modeled rather easily by means of the Boolean operations of union, subtraction and intersection. The power of solid modelling lies, therefore, in the operations that can be applied to the objects.

For the purposes of architectural design, the subtraction of solids matches the conception of interior space as being carved out from a solid. This abstraction can be used in the early stages of design to conceive an idea that can be developed later on, not necessarily with solids.

References.

5. Type

Type, a figure, archetype, model. The general form, structure, plan, style, etc. characterizing or distinguishing the members of a class or group. A kind, class, or group having distinguishing characteristics in common.

5.1 The break with the past.

One of the dominant themes of the artistic avant-gardes of the beginning of this century was the break with tradition. In the first point of his 1924 manifesto Towards plastic architecture, Van Doesburg wrote that “instead of using earlier types models and thus imitating previous historical styles, one necessarily must pose the problem of architecture entirely anew”. It is necessary then to suppress “all form-ideas insofar as this concept implies a predetermined type.”

This statement called for the right of the modern artist to create without having to refer to the past. In a time when a new aesthetic was under way, it was considered that nothing could or should be learned from the past. This radical position was part of a necessary ‘cleaning process’ aimed at the establishment of a new aesthetic, one that would be the genuine expression of its time.

Looking now in retrospective it can be argued if, in fact, modern art was something completely new, with no connection whatsoever with the past, as its apologists proclaimed. As an example, Van Doesburg’s drawings for the project of the Private House can be seen as a new way to understand and represent architectural space while, at the same time, they can be understood as a continuation of the work of Wright, that was known to Van Doesburg.

5.2 Types and the continuity of tradition.

A complete different approach towards the past is to consider that nothing new can actually be created, that everything that can be created is just another variation of a theme that has always existed. In architecture, the idea of continuity of tradition has been related to the concept of type. This association is mainly due to the definition of type written by Quatremère de Quincy, in a contributing article in the Encyclopédie Méthodique, in 1825.

In his essay on “Type”, Quatremère writes that “everything must have an antecedent. Nothing, in any genre, comes from nothing, and this must apply to all of the inventions of man. Also we see that all things, in spite of subsequent changes, have conserved, always visibly, always in a way that is evident to feeling and reason, this elementary principle, which is like a sort of nucleus about which are collected, and to which are coordinated in time, the developments and variations of forms to which the object is susceptible”.

Quatremère's more important contribution was to draw a distinction between the concepts of *type* and *model*. In the same essay, he writes that the *type* "presents less the image of a thing to copy or imitate completely that the idea of an element which ought itself to serve as a rule for the model. Thus, one should not say (or at least one would be wrong to say) that a statue, of the composition of a finished rendered picture, has served as the type for the copy that one made". The *model*, on the other hand, "is an object that should be repeated as it is; the type, on the contrary, is an object after which each (artist) can conceive works of art that may have no resemblance. All is precise and given in the model; all is more or less vague in the type."

Although without using the word 'type', the idea of an original model or figure in architecture has been addressed before Quatremère's essay. In the antiquity, it was considered that two were the original models for architecture: one was the house of God, the temple of Salomon; the other was Adam's house, the first shelter built by man (Vidler 1977). In the XVIIIth century, Antoine Laugier invented the concept of the 'primitive hut' to explain that all architecture derives from the first shelter that a man built: a hut built with wood posts, tied in their uppermost with beams and topped with a pitched roof. Similar references to the idea of the primitive hut are also found in the writings of other architectural theorists of the same period, as Francesco Milizia.

5.3 Type and scientific knowledge.

The idea of type, can only emerged retrospectively, looking back at all of the works of the past with the intention to find out the attributes that are common to all of them. As Giulio Carlo Argan has said, "in the process of comparing and superimposing individual forms so as to determine the 'type', particular characteristics of each individual building are eliminated and only those remain which are common to every unit of the series. The 'type', therefore, is formed through a process of reducing a complex of formal variants to a common root form." (Argan 1963)

This way to proceed can be considered similar to the one a scientist follows to describe the natural world. In the natural sciences, the different individuals are classified in genders or species by means of tables and diagrams. An entomologist, for example, would distinguish between insects with wings and without wings. Within the category of winged insects a new subcategory can be created for the butterflies, flies, moths and so on (Figure 47). The result of this taxonomy is a diagram which embodies the knowledge the scientist has about a particular topic. The significant aspect of the diagram is that insects themselves do not need to be drawn in order to render the diagram meaningful. The figures of the insects, that is their formal expression, is something independent from the diagram itself.

![Figure 47. A typical classification diagram.](image)

In a similar way to scientists, architectural theorists in the XVIIIth century committed themselves to the task of classifying the buildings of the past. One of the earliest examples of this sort was done by Julien-David Leroy. In his book *Ruines des plus monuments de la Grèce*, published in 1770, he made a comparative analysis of the temples and churches of the past drawing them together and at the same scale. (Figure 48)
Similarly, J.N.L. Durand published in 1800 the *Recueil et parallèle des édifices de tout genre, anciens et modernes*, in which he organized the buildings of different styles of the past as Leroy did (however, he drew not only the actual buildings of the past but added to them others which were of his own invention). In his next book, *Le précis des leçons d'architecture*, Durand took a step further and produced a table showing a series of dimensionless diagrams based on the division of the square and the circle (Figure 49). This seems to be the logical step to take after all information about the past is has been classified: to extract the basic principles that underlay the particular cases, that is, the buildings themselves. In this engraving from Durand, those basic principles are represented as geometric diagrams, with no reference to any architectural form or any functional program.

![Figure 48. Julien-David Leroy. Comparative analysis of temples and churches.](image)

![Figure 49. J.N.L. Durand. Ensembles d'édifices résultants des divisions du quarre, 1802.](image)
5.4 Type and inner structure.

In a supplement of the 1821 edition of the *Précis*, the *Partie Graphique*, new engravings appear in which the diagrams are drawn together with the formal variants that can be created out of them. One of those engravings shows a diagram of a square with four other squares on the corners and, together with it, two possible formal solutions (Figure 50). The idea that is behind this engraving is that the geometric schema is the starting point of the design process, and that from a same schema an infinite number of formal variations can be created. (Madrazo 1992)

The geometric diagrams drawn by Durand are in fact the graphic expression of the type or in, other words, the diagrams represent the inner structure of a design. According to Argan, "(The type) has to be understood as the interior structure of a form or as a principle which contains the possibility of infinite formal variation and further structural modification of the type itself" (Argan 1963).

A similar relationship between the underlying inner structure and the formal solution can be appreciated in two projects for a Unitary Temple, one from Wright and the other from Kahn (Gazzola 1987). Both projects share a similar underlying structure, based on a square with four other squares on the corners, with a main space in the center. The way each architect interprets the same schema is different in every case. Wright places the stairs and services in all four corners, as an expression of the bilateral symmetry of the square (Figure 51). Kahn, also assigns the stairs and services in the corners, but only in two of them, emphasize one diagonal over the other symmetry axes. Also, where Wright maintains the squared form of the central space, Kahn uses a circle instead (Figure 52).
The most relevant differences, however, are to be found in the way the same scheme is translated into a coherent formal expression. From the outside, the project by Kahn can be read as made up of four free-standing boxes in the corners, guarding the circular dome in the center (Figure 53). Solids are pierced and surfaces cut, in a way that contrasts with the clear volumetric expression of the whole.

In Wright's Unitary Temple, the four corners can also be read from the outside as independent elements but, unlike the project from Kahn, they are more integrated into the whole (Figure 54). From the outside, the building is read as a group of masses, which are strongly tied to each other, with a central element (the cubic central space) emerging from bottom up at the center.

Looking together at the drawings from Durand, the project by Kahn and the building of Wright, the separation between inner structure and formal expression is revealed. What is different in every example takes place in the realm of the formal expression, and not so much in the basic principle, the type, which in all three cases can be considered as one: the square plan with four squares in the corners and a central space. It is in this context, that the sentence of Kahn, 'what will be has always been', acquires full meaning.

5.5 Form as the type.

This characterization of the type as the inner structure, separated from the formal expression, can be compared to another approach according to which form, more precisely, the most elemental forms, represent the type. According to this interpretation, what the three examples discussed earlier have in common is that all three of them have a square form in plan.

For Peter Eisenman, the Platonic solids, like the cube or sphere, constitutes the 'generic' form. They are an a priori condition that the architect cannot avoid when he is designing. What the architect can do is to adapt the generic form to the particular conditions of a design. A design becomes then the 'specific' form. Einseman's contention is that generic form has its own laws which will be part of the design in which they are used. For example, a cube or a sphere are centroidal forms while a cylinder is linear. A design made from a cube will necessarily have the same properties of centrality as the generic form 'cube' has.

The idea of adaptation of a generic principle to a particular situation is behind Eisenman distinction between generic and specific form in architecture. In his case the generic principle are the Platonic solids; pure forms lacking, in principle, of any architectural meaning.

Other architects have looked for the principles not in the neutral form but in the existing formal solutions of the past. In a housing project for the historic center of Marburg, O.M.Ungers re-interprets some of the traditional houses of the area using a different formal language (Figure 55). For Ungers, to design a building is a matter of transforming some previous forms: "formation is inconceivable without transformation, and inversely there is no transformation that does not produce new formation in its turn." (Ungers 1982)
In one of the houses, for example, a traditional slate pitched-roof is transformed into a steel and glass framed-structure. More important, however, is that the acceptance by the architect of a certain type helps to set a limit to the design exploration. In spite of the differences between each house, all of them as a whole respond to the same theme.

5.6 The definition of a type.

As Argan contends, “a type cannot be the result of an arbitrary invention, but the deduction of a series of historic experiences” (Argan 1961). What the architect can do is to identify a type, as Ungers did in the Marburg project, and then explore a design within the limits established by the type itself.

This idea can be illustrated with a drawing by Dieter Schaal (Figure 56). A series of variations coming from a basic primitive hut are shown in the illustration. The first drawing on the upper left can be considered as the type. In its simplest expression the hut can be read as a box to which a triangular prism has been added. In the following variations of that type, a stair is added, the box perforated or replaced by four columns, or made smaller. In spite of the variations though, each single case can still be defined as a ‘primitive hut’.

Figure 56. Dieter Schaal. Das Haus.
What is graphically explained in this drawing is that the type has the potential to become each one of those variations. The most simple definition of the type embodies an infinite number of formal variations than can unfold at a certain moment. Thus, the type and the variations produced from the type, work in conjunction. It is only through comparison of each variation with the basic type that the attributes of the type itself can be discovered. For example, if a variation is created that does not have a triangular prism as a roof but a half-domed instead, we can question if the condition implicit in the definition of the type refers to the specific triangular form or only to the fact that one solid is on top of the other.

Some of the ideas that are in Schaal’s drawing are also present in the drawing of Stirling for the Electra bookshop in the Venice Biennale (Figure 57). At certain moment in the design process, a basic configuration of the project was determined: the small volume in the front, the longitudinal shape with a rounded end, the vertical chimney (recalling a ship), the sloping roof and the overhanging eaves. Once the basic elements of the design have been fixed, they can be seen as a type from which multiple formal variations can be created. The drawing of Figure 57 shows different solutions which result from the substitution of the small volume in the front. What is significant in this case, is that the changes only affect to one of the parts of the original type definition. The chimney and the longitudinal part of the building are not changed, they remain as a fixed attribute of the type.

Figure 57. J. Stirling. Electra Bookshop for the Venice Biennale.
Regardless the path the architect takes to arrive to the type, there seems to be two distinctive moments in the design process: the ‘moment of the typology’ and the ‘moment of the formal definition’ (Moneo 1978). First the architect chooses the type he wants to explore; then, in a second step, a formal expression is given to the type. The first moment, the selection of the type, can be considered as the objective part of the process, whereas the formal definition is purely a subjective one.

5.7 Type in computer-aided design.

Many of the ideas that has been discussed above about the concept of type in architecture can be found in the field of computer-aided architectural design, and in the realm of computing in general. In programming languages, the most basic use of the idea of type refers to the classification of data. In Pascal, for example, a variable can be assigned to the type of the ‘natural numbers’, or to the type ‘real numbers’.

In computer-aided design, shapes and geometric objects are often defined as types. A shape defined as a type, for example, a rectangle, can be instantiated as to generate other rectangles. The shapes thus created are called instances of the type ‘rectangle’. If the dimensions of sides of the type ‘rectangle’ are not fixed but they are defined as parameters, for example the ‘width’ and the ‘length’, then the type is called a parametric type.

The instances of the parametric type ‘rectangle’ could have different dimensions for the ‘length’ and the ‘width’ but still have the same essential properties as the original type. According to this, a square would be an instance of the type ‘rectangle’ in which the parameters ‘width’ and ‘length’ have equal values. Thus, the properties that define the type are the ‘essential’ properties (a parallelogram with four right angles), while the properties that are particular to every instance of the type (the length of the sides) are the ‘accidental’ properties (Mitchell 1990).

The application of parametric types has led to the idea of parametric design, one of the earliest paradigms in the field of computer-aided design. Once the structure of a design is understood, its shape can be described with a programming language in a way that formal variations can be created automatically after assigning values to the parameters that define the type. A type can be parametrized in a simple way or in a very sophisticated one. Depending on how complex is the description of the type, the formal variations that can be produced by assigning values to the different parameters will be more or less expectable. (Sometimes it is difficult to recognize that an instance actually derives from a particular type).

The idea of the separation between form and inner structure constitutes one of the basic principles in computer-aided design. The objects that a computer-aided design system displays on the screen are just the graphic expression of the computer database. What is important in a drawing done with a computer, is not the drawing itself but the inner structure of the drawing. In the words of Ivan Sutherland, "to a large extent it has turned out that the usefulness of computer drawings is precisely their structured nature... The drawing itself has properties quite independent of the properties of the object is describing" (Sutherland 1975).

For the purposes of design representation, form is for the computer, at this moment, irrelevant. What is important for the computer is the underlying structure of the form, rather than the form itself. For the human designer, on the other hand, form is the meaningful component in the design, whereas the underlying structure is hardly made explicit. This fact represents a dilemma in the use of computers to design, since it makes communication between computer and designer difficult.

The division between form and inner structure is also behind the idea of substitution. A given configuration of shapes modeled in a computer are susceptible of being replaced automatically by others. Thus, for a designer a computer offers the possibility of the exploration of formal alternatives of the same scheme (Madrazo 1992), providing the designer is aware of the structure of his design. A consequence of the same principle is the idea of propagation. When a type is redefined, all instances of that type will automatically be updated to reflect the changes.

Schaal’s illustration of the primitive hut and the variations is the expression of what is called an object-type in object-oriented programming languages. The basic type has not only information about its shape but also has built-in procedures which allow to develop a stair or to replace the box by four columns. These transformations are valid because the operations to create the stair, for example, is part of the definition of the type.

In the field of Artificial Intelligence, design prototype is “a conceptual schema for representing a class of generalized heterogeneous grouping of elements derived from alike design cases that provides the basis for the start and the continuation of a design” (Gero 1990). As in the type definition of Quatremère de Quincy, type or prototype are concepts that express a similar idea: to set bounds to certain territory within which a design will be produced.
References.


6. System

System, a set or arrangement of things so related or connected as to form a unity or organic whole. A set of facts, principles, rules, etc. classified or arranged in a regular, orderly form so as to show a logical plan linking the various parts. A method or plan of classification or arrangement.

6.1 The Four Compositions of Le Corbusier.

In architecture, formal abstractions are more than just a mean to express an idea. The idea itself is also the product of the particular abstraction that an architect uses to conceive a building. For example, a building can be thought as being a solid or as a set of planes. In each case, the use of a specific formal system, one based on solids, the other on planes, will impose certain conditions to the ideas that can be developed within each system.

This relationship, between a formal system and the design that results from its use, is expressed in the drawing by Le Corbusier, The Four Compositions. (Figure 58) After having designed the Villa Savoye, Le Corbusier made with this drawing a self-examination of his preceding work. Looking back to his previous houses, he identified four different formal languages (compositions) which had been decisive in the design of each one.

In the first ‘composition’, the formal language is the one of mass and solids. The shape of the project, the La Roche house, is the result of cutting out mass from a solid. However, the shape of the initial solid, from which mass is subtracted, cannot be recognized in the final design. The initial solid could have been a rectangular prism, or an L-shape prism. Ultimately, the shape of the house is determined in terms of figure-ground: it is looking at the plan view that the shape of the house is properly understood.

In the second ‘composition’, the platonic solid makes the formal language. A rectangular prism is the main element of the project, the villa at Garches. Precisely, unlike La Roche house, the outline of the box can still be perceived in the building, in spite of the addition of secondary elements (the stair and terrace in the back facade).

The third ‘composition’ results from the dialectic relationship between two formal languages: one represented by the grid, the other by the mass. As in the second ‘composition’, the shape of a rectangular prism is clearly distinguished. In this case, however, the shape of the prism is created by the grid rather than by a solid. It is the grid that defines the volume of the building. The grid, therefore, is the main element of the design, taken over the role of the rectangular prism of the second ‘composition’. As Collin Rowe contends “the neutral grid of space which is enclosed by the skeleton structure supplies us with some particularly cogent and convincing symbol, and for this reason the frame has established relationships, defined a discipline, and generated form.” (Rowe 1976).
Looking now at the plan drawing of the third composition, it can be seen that the regular distribution of dots/columns marks the area of the project. In a second step a solid is positioned within the area previously defined by the grid. This solid could stand for a room or a circulation core in the actual building.

The fourth 'composition', which corresponds to the Villa Savoye, is a combination of the formal languages described before. On the one hand, there is the idea of mass, as in the first 'composition'. The solid, in this case, is limited to the upper floor of the house. Consistently with this, the court in the upper floor can be understood as the result of the subtraction of some mass from that rectangular prism. Unlike the La Roche house, the outline of a complete box can be perceived in the design. Because of the wall that closes the space of the court, the edges of the original box are still perceived, in spite of the subtraction of the mass.

The grid of columns is the second formal system in this fourth 'composition'. Columns, in this case, do not appear on plan, as in the third 'composition', but only in the perspective. This fact reveals the contradictions involved in the simultaneous use of two different formal languages: one based on the solid, in the figure of the box (as in the first and second 'compositions'); the other based on the interplay between grid and mass (as in the third composition).

Since both formal systems, solid and grid, have a role in the design, the volume/space of the house could be determined whether by the spatial grid, as in the third 'composition', or by the rectangular box, as in the second one. The conflict in the Villa Savoye appears when both formal languages attempt to impose their respective laws, that is, when two readings are possible at once. Then, it is not clear any more if the house is a volume standing on columns, or if it is a grid with added walls that enclose the space (as the wall that closes the court suggests).

This conflict, far from being resolved in the final design, is materialized in the building itself. For that reason, the Villa Savoye can be considered as the built expression of the dialectic established between different formal languages in the conception of a design.
6.2 Villa Savoye: the dialectic of formal elements.

Each one of the formal languages identified by Le Corbusier can be assigned to a specific component of the building. A formal system based on solids is usually related to the exterior definition, or volumetric composition. The abstract grid of dots can be assimilated to the structural grid of the building. The solid that is intersected with the grid symbolizes the circulation core. The interior space is contained between the horizontal slabs of the grid.

Each abstraction of a specific component of a building could then be defined as a formal system. Thus, a design conceived in these terms, becomes the result of the interaction between the different formal systems that are set to play. The project for the Villa Savoye is a good example to understand how Le Corbusier conceives a design as the interplay of systems of elements. For Le Corbusier, "systems ... are the elements from which he builds the complex dialectics of his house designs" (Maitland 1979).1

In the Villa Savoye, each one of the systems - structure, circulation, interior and exterior - is characterized. It is possible to take each one of the systems in isolation, and to analyse how the design is the result of the interactions between the different systems: between structure and exterior, structure and circulation, interior and exterior and so on.

6.2.1 Structure.

The regular grid of columns distributed regularly on a square plan is one of the systems of the Villa Savoye. In plan, the grid consists of a regular distribution of dots on a square. This points are distributed regularly; there is no predominant orientation which is determined by the grid itself. Looking only at the plan, the grid can only be understood as a formal device; a symbol to which different meanings can be assigned.

Considering now the grid not as an abstract entity in plan, but as structural grid which is made up of columns and slabs, a different interpretation arises. In the first floor, the slab is extended beyond the limits of the square, thus marking an axis in the same direction as the ramp (Figure 59). When the building is approached from the outside, the cantilevered volume marks the entrance, which in turn is related to the position of the ramp inside. This way, two different systems, the structural and the circulatory (ramp), become interrelated.

[Image: Figure 59. Villa Savoye. The cantilevered slab acknowledges the entrance.]

6.2.2 Circulation.

The ramp is another characteristic system of the villa: it is the expression of the circulatory system, the element that channels the movement of persons through the building. Taking together the ramp and the grid, it becomes clear that every system has different formal properties which makes them incompatible (Figure 60). The regular distribution of the columns in plan, for example, does not facilitate the insertion of a ramp on it.

1 In his article The Grid, Maitland identifies these four systems: structural, volumetric, circulatory and geometric.
In order to achieve the synthesis of the whole design, a reconciliation of both systems is needed. Thus, some of the columns in the center of the plan change their position to allow the cutting of the opening in the slab, and to give support to the perimeter of the ramp. The interaction of two systems, structure and circulation, is resolved here by adapting one of them to the conditions imposed by the other. In this case, the ideal grid is sacrificed to allow the insertion of the ramp.

Fig. 60. Villa Savoye. The structural vs. circulatory system.

6.2.3 Interior.

The system of interior space consists of the volume trapped in between the slabs and the space contained within the limits of the ramp. The ramp, placed at the center of the square plan, recalls some of the central spaces in some traditional types as, for example, the central space of the Villa Rotonda (Figure 61). Thus, in the same way as the central space in the Villa Rotonda can be thought of as a void that has been carved out from a solid, the rectangular space contained in the ramp of the Villa Savoye is also a cut, if we consider the Villa Savoye as a solid mass supported by columns. According to this interpretation, the interior space contained within the ramp is the result of the interaction between the interior space system and the exterior (volumetric) system.

Figure 61. Villa Savoye. Comparison with the interior space of Villa Rotonda.

6.2.4 Exterior.

Another system of elements is the one that makes the exterior, or volumetric definition of the villa. Looking at the building from the outside, a multiplicity of interpretations about the dominant formal language in the design are possible. On the one hand, the building wants to appear as a solid box supported by columns. This is the case when the building is seen from the ground, at the eye-level, but an aerial photograph or an axonometric drawing raises some questions about this interpretation. (Figure 62)
More than a rectangular box, the upper floor has actually a U-shape, since a part of the volume has been subtracted to create the court. The integrity of the volume is restored by means of the wall that closes the court. This wall has the same kind of opening, the long window, as the other three sides which do have an enclosed space behind.

Therefore, the contradicting requirements imposed by the two formal systems used in the design (one as a complete solid, the other as a carved mass) are resolved closing the open side of the court with a fake facade. Once again, as in the relationship between the grid and the ramp, an ideal form (the platonic solid) is sacrificed in order to reach a compromise between the requests of the different systems in play.

Figure 62. Villa Savoye. The volumetric dilemma.

6.3 Ando and the structural system.

In the work of Tadao Ando, the structural system plays a major role in the design. For Ando a three-dimensional grid is the structural system. Effectively, unlike Le Corbusier in the Maison Domino, Ando conceives the structure not as columns and slabs but as a three-dimensional frame. Also, while in Le Corbusier's grid there are two different readings of the grid (one in plan as an abstract symbol, the other in three-dimensions as structural element), in Ando there is only one possible reading. The grid is at the same time a symbol, a formal device and a structural, constructive element.

In many of Ando's grids, the dimensions of both the columns and the beams are the same. The homogeneity of the dimensions of all members of the grid raises some questions about the role of the grid as a constructive support. From a structural point of view, the columns and beams should have different sections and also, their dimensions should change according to the loads that exist in the different parts of the building. From the two possible meanings of the grid, the formal and the structural, the formal one is then the most important.

In the project of the Wall House, the framed cubic units in which the structural grid is decomposed, are the elements that define the volume of the house (Figure 63). Instead of thinking of the house as a box, the volume of the house is defined by means of the assembly of the small frames. In a second step, another formal system, the planes/walls, come into play to enclose the volume previously defined by the grid.
6.4 Stirling and the circulatory system.

The understanding of a building as the dialectic relationship of formal systems is also present in the work of James Stirling. In many of his designs, the circulatory system becomes the predominant system. In the extension of the Tate Gallery in London, for example, the circulatory system is made out of a sequence of connected elements: entrance, lobby, and especially, the stair. Every element - entrance, lobby and stair - is an architectural event in a path that takes the visitor from the outside to the inside of the building. The lobby acts as a link between the entrance, and the interior space created by the stair. This interior space, which contains the main stair, makes the spine of the building, around which the other interior spaces are articulated (Figure 64).

The same scheme, based on the connection of architectural elements to create an architectural promenade, has been used repeatedly by Stirling. In the Sackler museum in Cambridge, the circulatory spine follows the same pattern as the one in the Tate Gallery (Figure 65). In this project, the strict separation of formal systems is manifested in the openings of the facade. The interior spine of the building is, by no means, reflected on the outside. The random distribution of openings in the facade shows that the skin is one system and the circulatory spine another one. There is no attempt to create a relationship between the different systems; rather, the independence of each one is stretched.
In the project for the Science Library in Irvine, the sequence of connected elements is also the main idea of the design, as the axonometric drawing clearly shows (Figure 66). In this case, the interior space is not defined by the circulation element. The interior space is a cylindric void connected to the access spaces in along one of its axes.

Figure 66. J. Stirling. Science Library, Irvine.

6.5 Gehry and the volumetric system.

In the architecture of Frank Gehry the dominant formal system is the one based on solids and mass. Most of his buildings need to be read mainly from the outside, as if they were big sculptures. The arrangement of masses does not follow a geometric pattern that can be read in plan or other projections. His designs are, more and more, the result of the free arrangement of solids in space.

The design for the Winton Guest House is an expression of these principles (Figure 67). The house recalls a massive sculpture composed of separate parts, each one maintaining its own identity. The characterization of the different solids is achieved in two ways: giving every solid a unique shape and a distinctive material.

In this example, the model can express better than any drawing the essence of the design. The shape of the house in plan is the by-product of the arrangement of solids in space. The plan is not the determinant of the architecture, in this case, but the mere outcome of the three-dimensional composition.

Figure 67. Frank Gehry. Winton Guest House.
6.6 Systems and the biological analogy.

A building, such as the Villa Savoye can be understood as a living organism, with each one of its different systems working in conjunction. Le Corbusier, in the text *The Home of Man*, referred explicitly to the analogy between a house and the human body. According to his analogy, the structural frame is to the house what the skeleton is to the body; the mechanical systems of the modern house are like the circulation system of the blood; the circulatory system of the villa, with its entrance and exit, can be compared to the digestive system; and the volumetric expression of the building can be compared to the external image of the human body. (Figure 68)

![Figure 68. Le Corbusier. The anatomical analogy, 1948.](image)

Alberti had already referred to the analogy between architecture and the human body. In the *Re Aedificatoria* he writes that "The most expert artists among the ancients were of the opinion that an edifice was like an animal, so that in the formation of it we ought to imitate Nature" (Alberti 1452). For Alberti, the beauty of a building has to be understood in terms of the relationship of the parts with the whole. Thus, the definition of beauty made by Alberti is the expression of the biological analogy: "Beauty is that reasoned harmony of all parts within a body, so that nothing can be added, taken away, or altered, but for the worse." (Alberti 1452)

There is, however, a significant difference between Le Corbusier's biological analogy and the one from Alberti. Le Corbusier thinks of the parts of a building in terms of inner organs (structure, circulation) while Alberti thinks in terms of outer parts (arms, torso, pediment) (Maitland 1979). One analogy has to do with formal appearance and composition, the other with function (Steadman 1979). Thus, for modern architecture beautiful was equivalent to useful or functional. According to the aesthetics of functionalism, a building is well-designed only if it fits its purpose.

Not surprisingly, machines were considered the models to imitate. A house should be like a machine that fulfils a purpose, so that its form should be determined by the function. Le Corbusier's admiration for aeroplanes, cars and ocean liners is due to the fact that those artifacts were a genuine creation of their times. Their form and their function made a unity. Then, a house should be designed in the same way as a machine ('the house is a machine to live in').

6.7 Design as a microcosm.

The analogy between architecture and the functioning of organisms (animals or machines) can be understood at two different levels. One is the direct analogy between the actual buildings and the organisms; the second is the analogy that can be established between the abstract world where a design is conceived and the real world where buildings, animals or machines belong. In order to explore this second analogy, it is necessary then to make a distinction between the actual *building*, which in fact could be compared to a living organism as Alberti or Le Corbusier did, and a *design*, as the necessary mental operation previous to the materialization of the building.

The architect does not work directly with the materials to make his creation, as the sculptor or the painter do. An architect first creates in the realm of abstraction and only in a second step the abstractions become a physical object. In the conception of the design, an architect creates a model of the real world, a microcosm made up of abstract elements. With this microcosm, an architect represents the phenomenal world in such a way that it becomes a coherent and logical system. (Colquhoun 1967).
Le Corbusier, in *Vers une architecture*, referred to a similar idea: "The architect, by his arrangement of forms, realizes and order which is a pure creation of his spirit; by forms and shapes he affects our sense to an acute degree and provokes plastic emotions; by the relationship which he creates he wakes profound echoes in us, he gives us the measure of an order which we feel to be in accordance with that of our world." (Le Corbusier 1923)

In the Villa Savoye, the interrelations between systems has to be understood within the abstract microcosm of the design. The structural systems or the circulatory system should not be understood as the actual columns and the actual slab of the ramp but as the abstractions of them (the grid in the case of the columns and the rectangle for the ramp). Similarly, the relations that the architect establishes between the systems have to be understood in the realm of the abstract world, and not in the physical one. In the physical world, a similar relationship should consider some external and objective facts, such as the law of gravity or the properties of materials.

In the abstract world, the subtraction of one solid from another is a mental operation, where the real materiality of the object or the means to perform the operation do not intervene. In the real world, on the other hand, a subtraction is experienced working directly on the matter, with the hands or with utensils (hollowing a mass of clay, carving a piece of stone). The experience of the real world will necessarily be a reference for the architect, but in the realm of abstraction he is not limited to the laws governing the physical world. The architect brings the experience acquired in the world of the senses onto the microcosm where the building is conceived.

The biological/mechanical analogy in the Villa Savoye should then be made in terms of comparison between the abstract and real realms, and not so much between the actual building and a living organism or a machine. In spite of the reference to the machine, this comparison does not explain so much the real meaning of the design as the concept microcosm does. More than a machine, the Villa Savoye is the materialization of an intellectual construct; a microcosm with a complex inner functioning.

### 6.8 Form and context.

The discussion about the biological analogy can be given another meaning considering now a design, more precisely the abstraction of a design, as a system which is able to maintain a dialectic relationship with some external conditions, or context. As it has been discussed earlier, the abstraction of a design can be thought of as a microcosm, made up of certain elements, (the formal abstractions related to parts of the building) and rules that control the relationship between elements. This microcosm can be defined now as a system, as a 'set of things so related or connected as to form a unity or organic whole.'

The rules of the system not only can control the interaction between the parts of the system but also the relation between the system and the external environment. This environment imposes some requests to which the system responds according to some built-in procedures. This way a design, as Alexander has proposed, can be thought in terms of the relationship between a form and a context. The goal of the design is to fit to the requests determined by the context: "every design problem begins with an effort to achieve fitness between two entities: the form in question and its context. The form is the solution to the problem; the context defines the problem." (Alexander 1964).

Following Alexander, a design cannot not be considered in isolation from its context; both the form and the context make an unity. The context, in his definition, does not refer to a physical environment but to a set of external and abstract conditions to which a design, the system, has to respond (at this point, an interesting exercise to make is to think which are those external conditions to which the system of the villa Savoye responds, or it would be able to respond to).

In the process of design, both the form and the context are the invention of the architect. A context does not exist as an objective set of requirements; it is the interpretation that the architect makes of those requirements what makes the context in this case.

### 6.9 Form and context: the Lineamenta-CAAD Futures exhibition project.

The project for the Lineamenta-CAAD Futures exhibition held in Zurich, was conceived in terms of the relationship between form and context; thinking of the design as a system with some built-in rules (Madrazo 1992). Four were the elements that made the system: the 'columns', a 'portico', a 'cross' and the transparent 'panels' that hung from the ceiling. (Figure 69)
Every group of elements in the system is characterized by certain rules. In the case of the columns, they start being simple boxes in the first row. In the second row they acquire the classic decomposition of base, shaft and capital. In the third row, the detailing of the joints and the capitals is more refined. In the last row, however, the columns no longer represent an increase in the level of detailing. The reasoning behind this is that, at that point, the columns start to interact with the cross.

The procedures that are embedded in the system also control the relationships between different classes of elements. In this case, the interaction between the columns and the cross brings about the change of the form of the columns of the last row, the one that is in direct contact with the cross. In the final solution, the columns of the last row have a cross shape at the base. (Figure 70)
Another set of procedures controls the response of the system to the requests of the context. A contextual request, in this example, is that a visitor who is moving among the columns will perceive the last row as a threshold before entering the area defined by the cross. The contextual request in this case could be defined as ‘make the columns transparent’. The system could react to this request in different ways: the columns could be made up of glass, without changing their form or, conversely, they could become a framed structure. (Figure 71)

6.10 Systems and the linguistic model.

A language is the expression of the notion of system. The basic atoms—the characters of the alphabet—are combined according to certain rules—syntax—in larger units, such as words or sentences that are used to name the elements of the outside world—semantics. The linguistic model has been traditionally applied to the analysis of many disciplines, and gained a new impulse in the sixties after the work of Chomsky.

According to Eisenman, in Le Corbusier’s diagrams are “implicit the vocabulary, grammar and syntax of a formal language.” (Eisenman 1963). Each one of the compositions conveys its own set of rules. The rules to transform a grid into a new one are fundamentally different to the rules that allow to subtract one solid from another. In each case, “the inherent order derives from a geometric reference, from the properties of the form itself”. (Eisenman 1963). A language is for Eisenman “a systematic organization of the codes of architectural practice, to define an apparently finite and stable number of forms and their correlated meaning within a closed system” (Gandelsonas 1982).

Eisenman’s interpretation of Le Corbusier’s diagrams in linguistic terms was influenced by Chomsky’s work: “The model of language adopted by Eisenman is, as is well known, structuralist: it derives from his personal reading of the theories of Chomsky and, as we have noted previously, such a model allows him to generate systems of relations among architectural forms” (Gandelsonas 1982). The hypothesis of structuralism is that the world can be decomposed in atoms of perception that then can be rearranged according to certain rules (Moles 1971).

The idea of generative grammar, (a grammar that, unlike prescriptive or descriptive grammars, provide instructions for the production of infinite number of sentences in a language) introduced by Chomsky, got an architectural expression in the early houses of Eisenman—House I, and so on. Those projects were, according to Eisenman, concerned with ‘syntactic structures’, with “the rules that underlay the theory”. (Eisenman 1963)

The houses of Eisenman constitute a system, where the elements and the rules that control them work in conjunction. Each design is then an instance among an infinite number of other instances that the system can generate (Figure 72). It is because of this that the house itself, considered as a finished design, lacks the qualities of unity that Le Corbusier projects have. Effectively, in spite of the fact that a similar reading in terms of systems and formal language is valid for both, Le Corbusier and Eisenman, the houses from Le Corbusier pursue the individuality of every design while the ones from Eisenman neglect (theoretically, at least) that possibility.

Figure 72. Peter Eisenman. House II, 1970.
6.11 Systems and computer models.

After the mechanisms that define a particular system have been understood, the system can be modelled in a computer in order to explore its behaviour under a variety of situations. This is in fact, one of the typical examples of application of computers in fields, like economy and urban planning. A model that reproduces the behaviour of economic agents, for example, can be built in a computer in order to predict the evolution of the economy.

The same principle can be applied to a system representing an abstraction of a design. The principles that are implicit in the Villa Savoye can serve as the basis of a computer model. It is necessary first to identify the components of that system and to deduce the rules that govern the system. Then, when the system is set under different contextual requests, the different reactions (formal variations) of the systems would be generated.

In the literature of computer-aided design and Artificial Intelligence, the term *case-based reasoning* is related to this idea. Certain knowledge can be extracted from a collection of particular cases which can then be instrumentalized to produce new case in a different context.

Current computer-aided design systems, however, do not provide much help in this direction. They cannot modelled a building conceived in terms of an active system, which can modify its form regarding different conditions. Models built with current systems are 'passive' models; they are geometric representations of forms, but the rules that control the relationships between forms are missing. Some basic computer-aided design concepts are used to fill this gap. For example, with *layers* it is possible to group elements of a design which have common attributes: the columns, the columns of the first floor, the walls, the inner walls, and so on.

The idea of *Shape grammars* is related with the application of a linguistic model to the generation of form. This paradigm, which has been mainly the contribution of George Stiny (Stiny 1980), is based on the recursive application of simple design rules in order to achieve complex shapes.

References.


7. Method

Method, a way of doing anything; mode; procedure; process. Regularity and orderliness in action, thought, or expression; system in doing things or handling ideas.

7.1 Method and architectural knowledge.

It is often contended that, unlike other disciplines, architecture lacks a coherent body of knowledge that defines its object. According to this perception, architecture can only be defined as a collection of examples. What defines architecture is the products themselves, that is to say, the different buildings made over time. Thus, architectural knowledge should be found not in theoretical treatises but in the buildings themselves. Every building embeds some knowledge, as it is demonstrated by the fact that we cannot avoid referring to a particular building when we discuss an architectural concept.

It can be argued that this situation is due to the fact that architectural knowledge has not been yet made explicit. When knowledge is made explicit, it becomes objective; it is no longer attached to a particular architect or to his work. Only then can a building be the result of the application of some generic principles to a particular situation, that is to say, only then a design can be the result of the application of a method. If that would be the case, an architect should not have to 'reinvent' architecture every time that he designs a building.

The quest for the systematization of architectural knowledge has always existed in architecture. In all epochs, attempts have been made to provide architecture with a sound body of knowledge. The need to systematize the discipline became particularly urgent after the introduction of the official architectural education. It was not possible to teach architecture in the Schools in the same way as it was learned in the ateliers. In order to turn architecture into a solid discipline, it was necessary a definition of architecture in generic terms, that is to say, it became necessary to go beyond what it was contained in the works themselves.

This was precisely the claim Durand made at the beginning of the XIXth century, namely, that the education of architecture could not be based on the study of particular cases but on the study of generic principles: "Un homme qui se propose de courir la carrière dramatique, n'apprend pas à faire telle ou telle tragédie; un musicien, tel ou tel opéra; un peintre tel ou tel tableau. En quelque genre que ce puisse être, avant de composer, il faut savoir avec quoi l'on compose" (Durand 1802).
7.2 Durand's method of composition.

For Durand, the analysis the works of the past was the way to determine the general principles of architecture. In his *Recueil et parallèle des édifices de tout genre,...* (Durand 1800), he made an exhaustive classification of the buildings of the different periods (and together with them he included others which were of his own invention). From the study of the buildings of the past he derived the elements that were common to all buildings, regardless their period or style.

The most simple elements that can be found in a building are walls, doors, arches, pilasters, columns and domes; these are the éléments des édifices. (Figure 73). The combination of those simple elements constitutes the parts (parties) of a building, which are the porches, lobbies and stairs. Finally, the arrangement of the different parts results in the building itself, which can be either public or private.

![Figure 73. J.N.L. Durand. Les éléments des édifices, Partie Graphique, 1821.](image)

After he has described the basic components of architecture, Durand introduces the idea of the mécanisme de la composition. For Durand, architecture is a matter of composition: "L'Architecture est l'art de composer et d'exécuter tous les édifices publics et particuliers" (Durand 1802). Following the classification and hierarchical structure of the elements of architecture, to design a building is a matter of applying certain rules to some preexisting elements.

Therefore, in the same way as the elements are made explicit, the rules to combine them can be made explicit as well. In this regard, architecture can be compared to the natural language: "Les éléments des édifices sont à l'architecture ce que les mots sont au discours, les notes à la musique" (Durand 1802).

With his method of composition, Durand attempted to make those rules explicit. The method is the expression of a process to design a building, progressing from simple to complex (Figure 74). The process that Durand proposes starts with the layout of the main axes of the composition in plan (*Nombre et situation des parties principales*). In a second stage, a new grid of secondary axes complements the main one (*Nombre et situation des parties secondaires*). Then walls are laid out along the axes (*Tracé des murs*) and columns placed within the areas bounded by walls (*Placement des colonnes*). In the last stage of the process, walls, porticos and stairs are drawn with detail.
Ultimately, the purpose of Durand’s method is to define where to start the design, what elements to use, and what rules to combine them. These three components - starting point, elements and rules - are, in fact, the key elements in the definition of a method in architecture.

7.3 The elements of architecture.

It should be noticed that the elements of architecture defined by Durand are not the same as the elements he uses in the method of composition. Contradicting his previous classification, the design in the illustration is not the result of the successive composition of walls, doors and stairs. Rather, the design is the result of the combination of lines (axes) in plan view according to the model established by some buildings of the past (villa Rotonda, for example).

Because of this, it should be questioned if the design is the result of the combination of those parts (walls, doors and so on), as Durand claims, or if the real elements of architecture need to be found elsewhere, namely in the realm of form. Precisely, the taxonomy that Durand uses to define the elements of architecture is more appropriate to describe the actual building than the way to design it. Any building has doors, windows and stairs but, the design of the building is done with abstract elements, such as the lines representing the axes of the composition. In this regard, Durand is putting at the same level concepts that belong to different realms: the abstract realm (lines, axes) and the physical realm (walls, doors).

Considering only the illustration, the method of composition resembles more a pictorial composition that a way to assemble architectural elements. In his method, Durand is not explaining how walls should be put together to make lobbies and entrances. What he is actually describing is a method of 'pictorial composition': first lay out the framework of the composition with a few lines and then proceed by increasing the detail.

One of the critical issues in the definition of a method, the elements with which to operate (lines, solids, numbers or words) was not accurately addressed by Durand. For Durand form was architectural form, the form related to a particular style of architecture. He established a clear separation between that form and geometry: the essential characteristics of the design were to be found in the realm of geometry, while form, the architectural form or style, was something added to it. Because of this, the composition of axes in plan view is one of the most relevant features of the method. The actual elements of Durand's method are the elements of geometry, and not the formal abstractions of architectural elements.
7.4 Eisenman: design as a process.

In the early work of Peter Eisenman, the main goal of his projects was to make the method by which they were generated explicit. In a series of housing projects- House I, and so on- the project is more than the result of the application of a process; the project is the illustration of a process. Eisenman's goal is not so much the design of the building itself, that is, the end product of the process, as to design a generic procedure which can generate one or many buildings.

Similarly to Durand's method, the generation process of one of the houses by Eisenman needs to start somewhere. The starting point, in this case, is not a geometric composition of lines in plan view. Eisenman's process starts with a solid/volume, the simplest formal abstraction of a building (Figure 75). Thus, the elements with which his method operates belong completely to the abstract realm: they are formal abstractions of a building, rather than the physical components of the it (as in Durand).

![Figure 75. P. Eisenman. Diagrams of House II.](image)

As it has been discussed above, Durand did not address thoroughly the issue of the formal abstraction of a building in establishing his method. First, he declares that the elements of composition should be found in the realm of the physical world (walls, doors). But, on the other hand, the elements that he uses in the method of composition belong to the abstract world (lines, axes).

Eisenman, on the other hand, draws a clear line between the conceptual and perceptual worlds. A design occurs exclusively in the conceptual realm and, for that reason, the elements of architecture are only formal abstractions and not physical elements. Because of the division he makes, Eisenman, unlike Durand, can formulate a method in which the elements to operate a clearly established. The contradiction that exists in Durand, namely, whether the elements are the physical walls and doors or the abstractions of those physical elements, does not occur in Eisenman.

7.5 Process as a sequence of transformations.

In the method proposed by Durand, and in the houses from Eisenman, a method is a step-by-step procedure evolving from simple to complex. Every step determines the next so that there are no 'jumps' in between. This way, the process becomes a sequence of continuous transformations. Moving from one stage onto the next is a matter of applying certain operations to a given configuration of elements.

In Durand's method, the nature of the transformations that he uses to move from one stage to the next is not clear. From the study of the illustration, the transformations can be understood as substitutions of certain elements by others (Madrazo 1992).
In Eisenman's designs, it is possible to arrive at a more precise formulation of the transformations that are taken place. The transformations always take place within the range of formal abstractions: a solid is replaced by a frame, the frame is subdivided into smaller frames, and so on. (Figure 76)

Consequently, the ultimate validity of a method, as proposed by Eisenman, depends very much on the possibility to make a precise formulation of the nature of each transformation. Eisenman's transformations are formal operations, which can be given mathematical expression: rotation, translation.

7.6 Design as materialization of the process.

The idea that a design is a potentially dynamic system which can be set into motion at a given moment is implicit in the early houses of Eisenman. In a more recent project, the Guardiola House, the project becomes the plastic expression of this idea. In a more clear way than in the earlier houses, this house is the 'built' expression of the method used to create it. (Figure 77)
The method in this case, is not a generic one that can be applied indiscriminately many times. The method is unique, as a work of architecture also is. It is a method to generate only one instance at a particular place and time. This is indeed a different attitude than the one shown in the early houses, where each house tried to be the illustration of a generic procedure.

Therefore, the Guardiola house, unlike the early houses, is characterized by the uniqueness of both the object and the method used in its creation. Starting with an L-shape, the different movements of the original element leave their imprint in the design. The whole project becomes then the sum of all the intermediate steps that go from the original shape to its last position along a motion path. (Figure 78)

Figure 78. P. Eisenman. Guardiola House, 1989-1990.

7.7 Computer and methods.

Only after a method to perform a task (whether in economics, engineering or in architectural design) has been devised, it is feasible to attempt its implementation in the computer. Computers, at this moment, can only solve problems which can be represented algorithmically. What computers can do is to execute very quickly a procedure that has been previously devised. Therefore, if a building can be the result of the execution of certain procedures by a computer, a method needs to be created first.

In this regard, the examples from Durand and Eisenman are relevant because they attempt to create such methods. Each one of those methods could be implemented in a computer. The question is not the possibility or impossibility of the computer implementation of an architectural method but the validity of the idea of method itself in architectural design. The acceptance of a method in architecture necessarily brings out the acceptance of some limitations to architectural knowledge: only what lies inside the boundaries of the method is valid; what remains outside the method is ignored or simply it cannot be understood. A method is therefore, necessarily exclusive; it has the potential risk to turn a particular perception of architecture into an absolute one.

One of the positive effects of the use of computers in design, even with the limited capabilities of the existing tools, is that the architect becomes more aware of the process of design. Modelling an idea on the computer imposes certain discipline on the designer. One stage of the design is transformed into the next by means of the operations that are available with the computer tool. However, even though the tool itself might suggest a way to address the design, the computer (at this time) cannot play an active role in the creation of the design. The consistency and coherence of the process remains the exclusive domain of the designer. Then, the challenge for an architect that uses a computer system today is to articulate his design logic with the instruments that are specific to computers.
References.


8. Representation

**Representation**, a likeness, image, picture, etc. A description, account or statement of facts, allegations, or arguments, especially one intended to influence action, persuade hearers, make protest, etc.

8.1 Design and representation.

Design can be understood as a process by which an idea originated in the mind of the designer is represented in an external medium. According to this, a sketch or a cardboard model are representations of the designer’s idea. This interpretation of design implies that there are two separate facts: an objective media which serves to materialize the idea, and the idea itself, which is purely abstract. A more correct interpretation is that the idea itself is embedded in the representation, that is to say, that sketches or models are not neutral, rather, they are dotted with some significance.

Taking this argument further, it can be argued that the idea is the result of the representation. Herbert Simon has contended that the solutions that can be found to a problem depends on the representation that can be made of that problem. Thus, to solve a problem simply means to represent it so as to make the solution transparent (Simon 1969).

8.2 Sketching.

Sketching is the simplest and most intuitive way for an architect to represent an idea. With sketches, the ideas can flow naturally from the mind to the hand, so that drawing and thinking become one and the same thing. Sketching is also an economic media; sketches can be done quickly and also be quickly discarded and replaced by new ones. They allow the fast exploration of the different aspects involved in a design.

Paul Laseau has used the expression ‘graphic thinking’ to express the unity that exists between the idea and its representation in the process of design. With regard to use of sketches, Laseau contends that they are important to the architect because they reveal how we are thinking about a problem, not just what we think about it (Laseau 1980).

In the sketches of Ungers for the project of the Hotel Berlin, the development from one sketch to the next shows how the architect is thinking about the design (Figure 79). Looking at all the sketches together, it can be derived that the relationship between a cylindrical form and a rectangular prism, is the topic that is being explored. In the sketch on the top, the cylinder stands out as a separate form. In the sketch right below, the cylinder and the rectangular mass become a single element. The same issue is studied not only in three-dimensional representation but also in plan. From one of the plan schemes it can be interpreted that a part of the figure is subtracted. In other plan diagrams, other combinations of rectangle, circle, and semicircle are considered.
8.3 The aesthetic of the line: Libeskind and Schaal.

The lines of the free-hand drawings have a different meaning when they are rendered with rulers and T-scale. Then, the line is no longer the vague trace outlining the contour of the figure. The line has a precise dimension, a beginning and an end; it can be measured. The straight line is the expression of geometric space. An object represented with geometric lines becomes also part of the same geometric space.

Typically, line drawings are used in engineering drawings, whose purpose is the detailed description of the geometry of an artifact at a certain scale (a building, object). Durand, for example, made an extensive use of this kind of drawing in the illustrations of his books. For Durand, drawings should be in accordance with the kind of architecture they express: "le dessin est la langage naturel de l'architecture; tout langage, pour remplir son objet, doit être parfaitement en harmonie avec les idées dont il est expression" (Durand 1802). Therefore, an architecture based on the economy and the simplicity of means, as the one Durand promoted, should be also represented with simple drawings.

The drawings of Daniel Libeskind illustrate the identification between idea and representation that Durand was defending. The project for a Museum in Berlin can be read in plan as a broken line: a tortuous path expressing the vicissitudes of the history of Jewish people (Figure 80). Consistently with the idea of the line, the representation of the design is also made with lines. However, an opposite reading could also be made: the design is a line because of Libeskind previous experimentation with line drawing compositions.
In Libeskind drawing, there is a comprehensive use of the different possibilities offered by lines: lines at different angles, dotted and continuous, thin and large, grouped, separated or intersected. (Figure 81)

The drawings from Dieter Schaal also explore the possibilities of the aesthetic of the line. The drawings published in his book *Architektonische Situationen*, are made up of precise lines, the minimum elements to represent the figures. Drawings are three-dimensional, whether in axonometric or perspective (Figure 82). The use of the same angles for the axonometric or the same view point for the perspective gives consistency to the ensemble of drawings presented in the book (the drawings that serve as introduction to every chapter in this publication are Schaal’s drawings).
8.4 Lissitzky: the identity of the idea and the representation.

Lissitzky’s painterly compositions are the counterpart of the engineering-type of drawing. In those compositions, he explores the aesthetic possibilities of lines and color surfaces to create, rather than to represent an object. That is to say, it is not that the object exists first (in the designer’s mind or as a real object) and then is projected onto a surface by means of orthographic projections. Rather, it is the representation itself that creates an object that did not exist before. (Figure 83)

Other aspects of Lissitzky’s work pertain to all the artistic avant-garde of the beginning of the century, namely, the aesthetic value given to the neutral geometric elements. Lines and planes are no longer the abstract elements of Euclidean geometry. They become tangible, visually activated, and even doted with soul and expression (Kandinsky 1926). A line is more that the connection of two points in space; the line can be different depending on its color, width or curvature. (Figure 84).
8.5 Eisenman's axonometric model

In the project for House X, Eisenman built one the models as a three-dimensional materialization of an axonometric drawing. The model only offered the right view when it was seen in the same position as the drawing. Any other position offered a distorted image of the design. (Figure 85)

This 'irony' illustrates the same sort of relationship between object and object representation as the one that was suggested in the work of Lissitzky. Both, Lissitzky and Eisenman, are inverting the terms of the equation: they deny the existence of an object independently from its representation. Both object and object representation are one and the same thing. As Gandelsonas has said "The axonometric model of the House X is a three-dimensional construction made to provide the image of a two-dimensional drawing. It does not provide knowledge of the object in a dimensional sense; it is not about reality, but about fiction" (Gandelsonas 1982).
Also in Eisenman, there is a consistency between ideas and the type of representation. Most of his projects are depicted in axonometric view. Axonometric drawings show the 'actual' dimensions of the object, without the distortion of perspective views. They are the accurate representation of the ideal object built on the Cartesian space (Figure 86). In this regard, the representations of the projects by Eisenman are very similar to the ones that a mathematician would make to show his investigations on a similar subject.

Figure 86. P. Eisenman. House IV.

8.6 New representations with computers.

In principle, computers are bound to offer new sorts of representation that architects can use to conceive and to communicate their ideas. It is difficult though to claim that computers are already providing these new representations. Very often, the design representations made on the computer reproduce the ones that existed before in other media: wireframe (hard line drawings), solid modelling (physical models), animation (cinema).

The challenge for an architect who wants to use a computer system to express his design ideas is to identify the potentialities of the different representations and to work within them. For example, any computer-aided design system available in the market today allows to work within the 'aesthetic of the line', as in the drawings from Schaal or Libeskind. Also, the virtual world that the computer creates is an expression of the inversion of the relationship object/object representation, as in the work of Lissitzky and Eisenman. Finally, a more challenging path is the one created by the possibility to design with animation. Architects start to face now similar problems that the film-makers had to deal with when movies were invented: the representation of space in motion. Even more challenging is to conceive a space or a design working directly with animation, rather than using motion to represent an existing idea.


