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Research

Inácio Vieira: Optics and Perspective as Instruments towards a Sensitive Space

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Abstract. The manuscripts of Jesuit mathematician Inácio Vieira (1678-1739) played a significant rule in treatise production in Portugal. The *Tractado da Óptica* (1714) and *Tractado de Prospectiva* (1716) address the nature and properties of vision, the deception and disillusion of seeing and the fundaments of perspective. Geometric properties of visual rays, principles of optical illusion and values inherent in the optical and mathematical representation of space are explored, together with practical applications in architecture and painting. Although he does not make an original scientific contribution, he formulates operative statements applied to the arrangement of a sensitive space. This approach to optics and perspective brings up the relationship between reality and appearance in which the production of an image lies in the fact that to show an object, one has to show it *as it is not*. Vieira's work forges links between optics (*perspectiva naturalis*) and perspective (*perspectiva artificialis*), analyzing image distortion through spatial perception, illusion and *quadratura*. Pursuing an empirical architecture, the simulated space of *quadratura* is understood as a challenge that creates a new dimension and experience of architectural space. Form and metric properties, from real and illusory construction, are interrelated contributing to an imaginary perception of spatiality. It is here that optics and perspective are established as architectural instruments for achieving a sensitive space.

Introduction

This present study examines optics and perspective treatises, searching for intersections between science and architectural design processes, seeking *imaginary architectures*. The connection between perspective theory and practical application depicts the interplay between built space (real) and represented space (illusory), pursuing an empirical architecture based upon simulations of *quadratura*, a technique of illusionary painting.[1] The possibility of an unlimited space beyond architectural form is given by perspective, not based on the construction of a tectonic reality, but on the appearance of two-dimensional architectural representation images converted to three-dimensional illusory architectural spaces. Form and metric properties, of both real and illusory constructions, are interrelated and contribute to the perception of an imaginary spatiality. It is then that optics and perspective establish themselves as architectural instruments and include spatial-visual perception in architectural conception.

Here we focus on the work of the Jesuit Priest Inácio Vieira, professor at *Aula da Sphera* (Sphere Class) in Lisbon, and his treatises on optics and perspective. *Tractado da Óptica* (1714) and *Tractado de Prospectiva* (1716). Vieira was also the author of a

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number of other treatises on subjects such as astronomy, pyrotechnic mathematics, catoptrics, dioptrics, hydrography (the art of navigation), chiromancy and astrology.

The Aula da Sphera

From the sixteenth to the eighteenth century, the *Aula da Sphera* of the Jesuit College in Lisbon played a major role as the main scientific institution in Portugal, ensuring education on physical-mathematical subjects and integrating scientific breakthroughs by hosting teachers from colleges throughout Europe.

The opening of the Jesuit colleges in Portugal coincides with the cultural and educative reform taken by King João III (1521-1557). The strategic plan of Jesuit teaching, *Ratio Studiorum,*[2] was adjusted to suit the national circumstances and complied with the royal request to open the institution to the public. It provided lectures on the mathematics necessary for techniques related to the art of navigation. This departure from the pedagogical norm resulted in a tendency to emphasize the practical applications of science, avoiding higher levels of abstract theorization, and the use of vernacular instead of Latin in classes.

The organizational level of the network of colleges developed skills of communication and cooperation, gathering and exchanging scientific information, but was conditioned, however, by scholastic theology intended to glorify Catholic Church. Scientific contents and the aggregation of new arguments were established under the solid principles of the Counter-Reformation, where knowledge was managed in an agreement between faith and reason tending towards unity: Christ (verb) and God (truth) are converted into human speech and action. As such, the primary source of knowledge is, according to Aristotelian scholasticism, sensible reality, because the idea does not exist outside the world presented to the senses.

The *Ratio Studiorum* provided guidelines for mathematics education. The first concern was an introduction to Euclid's *Elements*, which was followed by an introduction to the parts of geography and astronomy that were related to geometry. Every month students were requested to solve a famous mathematical problem, which, in the presence of philosophy and theology students, was discussed in accordance with the ideological standards of the Jesuits, reflecting the approach to science as knowledge of the natural and recognition of the divine.

The restoration of Portuguese independence in 1640 led to a revision of the educational programs, redirecting them to suit the needs of the military war with Spain, and make up for the lack of specialized technicians. Subjects such as arithmetic, geometry and algebra became part of the programs providing the essential foundations for architecture (included in this institution by royal request), training architects to reshape the military infrastructure.[3]

With the resumption of international relations and positive economical development in the early eighteenth century, a profound change took place in the scientific scene in Portugal. Travel and scientific exchange were encouraged, as was the reform of educational institutions, where the Jesuits strengthened their influence and presence within the court, profiting from royal patronage. The *Aula da Sphera* played a central role in the Portuguese scientific educational panorama, which is testified to by the number of foreign teachers who held positions (about one-third of them all), making it possible to ensure that the curricula was continually updated.

The treatises by Inácio Vieira

Despite the cosmopolitanism and updated contents presented at the *Aula da Sphera*, Portuguese treatise output during the seventeenth century is limited and often devoid of the kind of reflection and scientific reasoning required to set forth subjects such as optics and perspective systematically.

With regards to perspective, related to the representation of reality and the instrumental processes of painting and architecture design, the "… texts didn't work as manuals where authors treat the practice of painting or drawing, but rather were conditioned by literary matters and exaltation of painting as a liberal art" [Melo 2002: 413]. According to Saldanha [1998: 85], the artistic treatise is deprived of the necessary scientific content by joining the apology in an affinity between literary and pictorial form.

In this situation, the theoretical reflection and systematization carried by Inácio Vieira is noteworthy. As teacher at *Aula de Sphera*, he drafted the *Tractado da Óptica* (1714) and the *Tractado de Prospectiva* (1716),[4] organizing the state of knowledge regarding the *nature and properties of vision*, the *errors and disappointments of view*, the *fundamentals of perspective* and *Reflection*. The treatises cover the geometric properties of visual rays, the principles of optical illusions and optical mathematical values inherent to the representation of space, along with the consequent practical applications in architecture and painting and the possibilities of projecting images in space.

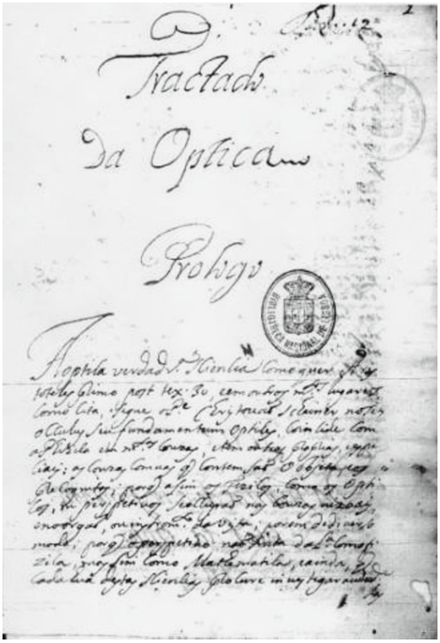

Fig. 1. Inácio Vieira, *Tractado de Óptica,* 1714 (Biblioteca Nacional de Lisboa, Codex 5169), fol. 1

Fig. 2. Inácio Vieira, *Tractado de Prospectiva,* 1716 (Biblioteca Nacional de Lisboa, Codex 5169), fol. 1

Although he did not achieve an original scientific contribution, he formulated an operative step towards a full theoretical understanding of the subject, reiterating the positions of seventeenth-century Italian, French and German treatises: "…its omnivalent approach often introduces practical examples based on direct experience of authors of reference …" [Raggi 2004: 528]. These are the first Portuguese works to recognize the importance of proper representation of pictorial space, integrating *quadratura*[5] and scenography[6] design with current knowledge and practices, in accordance with the prevailing rhetoric and proselytizing mission of art in erudite Jesuit circles and European courts. Although the treatises remained in manuscript form, these syntheses were diffused in the college, through communication of its contents in the classroom, or by the circulation of manuscript copies made by students.[7]

Vieira's works condensed scientific knowledge developed over the 1600s, ranging from the dominance of theoretical and practical Italian experience (Pozzo) to the French essays (Dechales), German systematizations (Kircher, Schott and Scheiner) or pre-modern sources (Ptolemy, Euclid, Vitruvius, Alhazen, and Witelo). The two treatises discussed here developed a progressive investigation of the arguments relating vision and representation of a visible or imagined world, both dealing with the conditions of seeing, *óptica*, and the geometric interpretation of vision, *prospectiva*, simulating visual reality through its two-dimensional representation. They collect knowledge and tools converted into working logic for architects, painters and set designers, establishing the principles of a sensitive space.

Here, the exploration of perspective is affiliated with the effort of a *prós opsin euruthmia* (proportion in agreement with visual impression), gathering the beauty of form according to the subjective impression resulting from the deception of vision, once the ideal of absolute mathematical proportions is inaccessible to the architect by distortions triggered by the process of seeing. From this logical point of view, perspective does not refer to an exact image of the world, but to its appearance. Spaces of *quadratura* challenge perception, creating an intellectual awareness of a sensitive dimension of architectural work on which it is "built". Perspective raises a simulacrum structuring a seeming and mental reality.

Tractado da Óptica, *1714 (BN Codex 5169)*

The *Tractado da Óptica*, or Treatise on Optics, organizes the subject into two branches: the first physical, relating to the "*organ, or instrument of vision*," and the second optical (or perspective), relating to *"visual things"*. This identification structures the document. While physics treated the line "*as a physical object*", generally regarding anatomy and a physical understanding of vision and the viewed image, perspective treated it as a mathematical object, regarding an abstract system, converting how we see it into geometric-mathematical facts.

As such, the first part, "*the properties of the eye fundamental to optics*" (fols. 2 to 95), explores the anatomy of the eye; the second part, "*the nature and properties of seeing*" (fols. 96 to 246), examines the conditions of sight towards perception of displayed reality, presenting some solutions to rectify the perceived form. The end of this second part, an Appendix entitled "*From some propositions pertaining to this matter*" (fol. 196), is based upon the understanding of differences between real and perceived image as result of visual perception, analyzing a possible manipulation of perceived image and reality. Material collected here constitutes the support for the speculations of the third part, "*Of the mistakes and disappointments of view*" (fols. 247 to 375), which explores distortion of reality for the purpose of deception.

It was through the exploitation of optical illusions that the Church enthusiastically promoted the development of mechanisms to support Counter-Reformist rhetoric. In "*The precious appearances made by nature*" (fol. 320), natural phenomena are interpreted, for subsequent application in "*How to represent by art what nature displays*" (fol. 329), developing a "Handbook of miracles," turning knowledge into a capacity for the deception of vision and obstructing viewer's reason "*without suspicion of diabolical art*".

At the beginning of the third part, Vieira seeks to understand how our senses condition our relationship with bodies displaced in space. How does the deception of our senses interfere with judgment of reality?

> *… by corrupting the senses, judgment, depending too much on them, would fall into error … as our reasoning was in many things dependent on senses, if they do not present the object's truth, reasoning can't be undeceived* [Vieira 1714: 247-248].

The mistake of judgment regarding reality is a consequence of the deception of senses conditioning reasoning and understanding of the world. Thus, Vieira refers to painting as a condition of deception and simulacrum of the act of seeing; he maintains, however, the differences between representation and the image "painted" on the back of the eyeball, as a process of seeing.

Philosophical discussion in the Baroque age compared the real world and the perceived world in which visual illusions offered by perspective science as playful instruments became overburdened with religious and scientific values, establishing a feeling of uncertainty. This uncertainty over sensitive reality was criticized by Descartes in *Discours du méthode* (1637), putting senses under the doubt of reason. In his discourse, the understanding of the world, based on a universal mathematical basis, order and measure, should ignore everything that comes from senses and tradition. This rationalization in the search for truth was developed in contrast to the Aristotelian empiricism, and especially to the overestimation of the five senses, especially vision.

In Inácio Vieira's treatise, reflection is built upon an exaggerated value of vision, considering the mistakes of the eye as mistakes of reason, once rational judgment, according to the Aristotelian conception of natural knowledge, is blocked from a direct relationship with the outside world depending on the senses. Furthermore, the excessive rationalization of Descartes is downplayed by Vieira, given his agreement with the Jesuit concept of empirical science: "*This very same issue is deeply developed by Descartes, but since he has never exercised it, it misses many things*" [Vieira 1717: 690].

The treatise goes into issues of visual angles when, without referring directly to Euclid's propositions, it explains them through the observance of reality. The section entitled "*From some curious problems for deceiving and undeceiving sight*" (fol. 263) introduces practical arrangements of "error". From this point forward, the author begins a long statement of optical/perspective problems leading to the production of anamorphosis on a wide range of surfaces, with different purposes, along with several procedures for their resolution.

In "*How to draw some square images*" – the first problem (fol. 264) – the images produced to entertain senses are taken from Dechales' *Opticae, libro secundus*.[8] The second problem (fol. 267) further examines the construction of anamorphic figures by the "*outline of a deformed image, which viewed from a particular place seems perfect and well developed*"; the text coincides with the statement of Dechales and the drawings are similar to table 12 of Niceron's treatise.[9]

Fig. 3. Inácio Vieira, *Tractado de Óptica* (1714), fol. 247

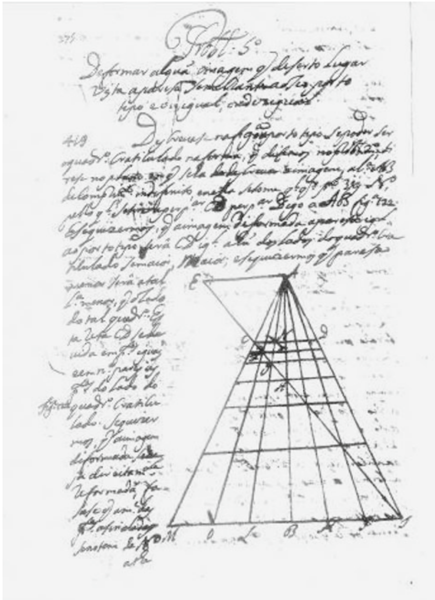

Fig. 4. Inácio Vieira, *Tractado de Óptica* (1714), fol. 275

"*Deformation on the conic from the images in the flat plane*" (fol. 279) guides the reader on how to produce a perspective device, automating perspective through the materialization of its geometric elements (*board, point of view, visual ray*), without the use of geometric-mathematical procedures. Kircher's *mezoptico*[10] instrument (explained via Schott) has a dual function, making it possible to draw what is visible, the space beyond the framework and to project image into space through "*light and shadow*" or "rope." By placing a light source at the viewing point, the image projected into space is admitted in any surface and with any level of deformation without using the abstract procedures based on the distortion of grids presented in the previous chapter. Later in the treatise, in "*How to project any figure in interrupted planes to be seen from a certain place*" (fol. 317), the discussion returns to perspective machines, with references to Dürer and Maignan (also quoted via Schott), and including their expedients for anamorphic construction.

Concluding the variety of possible implementation for anamorphic constructions, the twelfth chapter, "*Deformation of images in any other planes mainly in the interrupted*" (fol. 314) explores the deformation of an image on a specific space, entering into the explanation and practice of *quadratura*:

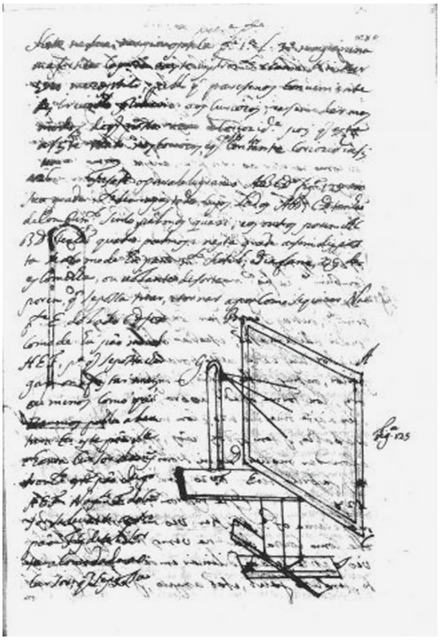

Fig. 5. Inácio Vieira, *Tractado de Óptica* (1714), fol. 280

Fig. 6. Inácio Vieira, *Tractado de Óptica* (1714), fol. 283

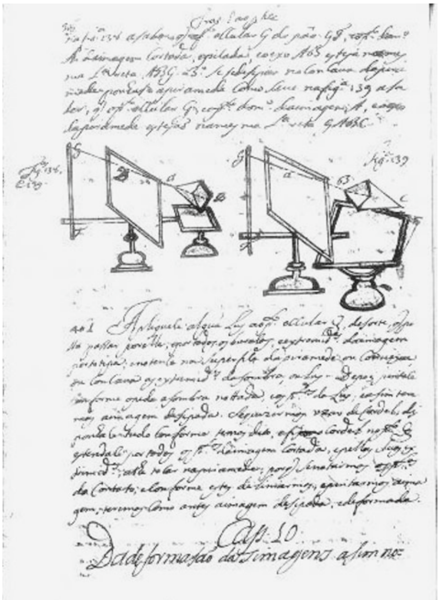

Fig. 7. Inácio Vieira, *Tractado de Óptica* (1714), fol. 306

> *From what we have said, it is possible to deform and project images in any type of plane and observe similar geometrical deformations. However, mechanically it can be worked easily by light and shadow, by string, or with optical beams directed to the plane* [Vieira 1714, 314-315].

The first problem of this chapter (fol. 315), "*How to deform images in interrupted planes which by approaching or moving appear as projected parts, and are seen perfectly only from one place*", provides a method to image projection into space to be observed (according to the prototype) from a specific position. To achieve this, Vieira uses an optical instrument of Kircher which Vieira calls *mezoptico*, which, set in place and with strings extending from the optical spot, outlines the desired image on any kind of plane, "… *there is no surface, no matter how misshapen and discontinued, on which it can't be done*" [Vieira 1714: 317]. Here a second use for the *mezoptico* instrument arises, by reversing the operation of Dürer's perspective machine. While in a previous paragraph, projection was based on image delineation through light beams passing the perforated points in an opaque support; here, despite the insistence on light spot and the projection of points, the author refers to the use of strings to determine each point in space on surfaces that receive the figure. In the *Tractado de Prospectiva* we will again find these two steps. However, these procedures grew out of the misgivings of Pozzo between an ideal system (based on projecting the image from a light source) and the existing circumstances (construction from strings stretched into space from the viewing point), consequent to technical constraints and space dimensions in which image is delineated.

The application of these principles makes it possible to achieve a high degree of illusion when, for example, "… *a beam can be painted so that it really seems to be set on the walls* …" as in the case of "… *the entrance hall of S. Vicente monastery, the choir of S. Francisco and the tomb of the Cathedral* …", referring to the existing examples of *quadratura* in Lisbon:

> *We may notice that paintings executed in this form have a special beauty and marvel. But, once the observer is displaced from the viewing point, painted constructions appear broken, smashed and totally gone, columns and porticos seem to move and fall; although, returning the observer to this spot, image become into its perfect figure, similar to its prototype* [Vieira 1714: 317].

Here, Vieira shows, according to the construction from a single *viewing point*, its illusory effects and how the image changes according to the observer's movement. Represented architectures arise with the *body*, as a tectonic fact, and are disrupted or collapse as the observer moves. This fact leads us to the ideological values exposed by Pozzo in the dogmatic defence of a unique point of view. According to Pozzo, contemplation of transcendent facts of faith would only be perceived when the observer was placed in the right location – the path of faith – outside of which the sublime crumbled. This thought integrates the illusion of a sublime truth in the same sense of contemplation expressed by Ignatius of Loyola in his *Esercitia Spiritualia*: "For, if the person who is making the Contemplation, takes the true groundwork of the narrative, … he will get more spiritual relish and fruit …" [Loyola 1538: Second Annotation].

Tractado de Prospectiva, *1716 (BN Codex 5170)*

In the Prologue (fol. 1)of the *Tractado de Prospectiva*, or Treatise on Perspective, the author identifies the scientific domain of perspective as the field of mathematics related to everything that concerns the eye. Its use is restricted to the representation of objects that:

> *… drawn this way will form into the eyes a very similar image of the object, the very same that the object would form if presented to the eyes; from which arises, that all painting belongs to perspective* [Vieira 1716: 1].

Organized in six Tables, the treatise systematizes arguments related to perspective science, from ground rules to complex practical application: "*Fundamentals of perspective*" (fol. 4); "*Projective scenography*" (fol. 34); "*Appearances of bodies in any sort of position*" (fol. 222); "*Ceilings, and vaults*" (fol. 270); "*Composition of various boards, reflection and shadows*" (fol. 298); "*An instrument useful in practice*" (fol. 333). This sequence is interrupted by an "*Opportune tour in civil architecture, single line about the orders from this Science*" (fol. 90), which explores architectural orders, principles of composition and perspective interference into architecture. At the end of the treatise, a supplement is added to explain the "*Method of Brother Pozzo dealing with spiral columns*" (fol. 360).

In the first table, "*Fundamentals of perspective*", the relationship between the observed reality and the represented one is explored, with definitions of basic concepts (*Picture plane, Base line, Main convergence point, Horizontal Line, Distance line, Distance point, Mainline, Ray, Objective Line, Appearance of objective line, Objective plane*), together with its main theorems. The discussion is practical rather than speculative, since demonstration of fundamental concepts is based upon experience with the perspective device (which was previously presented in the treatise on optics).

The second table, "*Projective scenography*", is about the practice of perspective representation: achievement of plan perspective and, by obtaining heights, definition of construction volume.

While the first table followed the structure of Dechales' treatise on perspective, the second table abandons this for cross-reference, comparing different procedures for each construction. It begins by giving guidelines for establishing the observer's position in front of the object. "*The location of the observer must be outlined, viewing point, that according to Andrea Pozzo is the only one … which easily allows us to obtain the main convergence point and distance points*" [Vieira 1716: 36]. Pozzo upholds the uniqueness of the point of view[11] and, through a triple space projection (plane, section and elevation), he sets out the fundamentals of perspective for the setting up of illusory images in a real space.

The presence of Pozzo's procedures in Inácio Vieira's treatise, through long quotations and explanatory figures, is important in the Portuguese panorama of perspective science history, confirming just how up to date the work was, since the first Portuguese translations of Pozzo's *Perspectiva Pictorum et Architectorum* (1693) only appeared in the 1730s. The inclusion of this source is an acknowledgement of Pozzo's practical procedures and its dissemination through Vieira's educational efforts at *Aula da Sphera*.

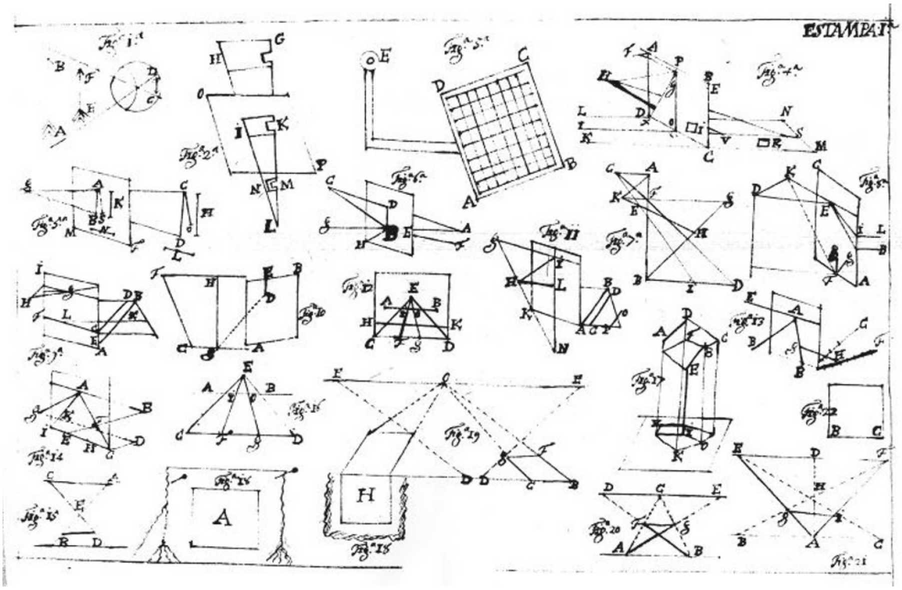

Fig. 8. Inácio Vieira, *Tractado de Prospetiva* (1716), Table 1

The practice of perspective begins throughout plane figures on the ground floor facing several parallel constructions: *"This practice is from Andrea Pozzo … Father Dechales tell us to do this way"* [Vieira 1716: 36]. While in Pozzo's example, the square is obtained by determining the depth of an edge; according to Dechales, the square is constructed by the perspective of its diagonals. Both cases are translations where nomenclatures and constructive sequence coincide integrally with the sources.[12]

In the sequence of obtaining grids and pavements in perspective, Vieira interrupts the explanation of this argument to engage an "*Opportune tour in civil architecture*". He deviates from his main sources justifying that perspective

> *… can't take a step without knowing the proportional principles and measures of the five architectural orders … perspective must be taken along with architectonic knowledge, … once perspective is demanded to outline in plane, with colours and brush, the gallantry of Architecture … that the well-tempered architect has put into solid …* [Vieira 1716: 90-91].

It explains the need for architectural representation to obey the same compositional principles as *"solid"* architecture. In this *tour*, which quotes Vitruvius, Serlio, Vignola, Palladio, Scamozzi and Dechales, the sequence and content of the definitions presented lead us to believe that Vieira knew Ferdinando Galli Bibiena's *L'Architettura Civile* of 1711. If this source could be proved, given the already proven inclusion of Pozzo's procedures, the up-to-date nature of the treatise would be truly remarkable.

In his architectural treatise, *Regola delli cinque ordini d'architettura* (1562), Vignola announced the preparation of a treatise in perspective, *Le due regole della prospettiva pratica* (1583), which was to make it possible to use perspective to evaluate optical distortions in constructions, once the rules for architectural ornaments were established. The comprehension of optical distortion brings up the relation between reality and appearance identified by Plato, in *The Sophist*, in which image production lies in the fact that to show an object one has to show it as *it is not* in reality. Plato compares two categories of imitation: one that reproduces reality in its true metric proportions, producing awkward images due to optical distortion; the other in which artists neglect true proportional ratios, at the expense of material truth, given precedence to appearance. It follows that representation of reality re-creates the appearance of things; just as in architecture the correct appearance of the proportion of elements is only possible through mechanisms of perspective.

In the fourth table, *ceilings and vaults*, the author explores questions about the practice of *quadratura* and the representation of illusory architectures leading towards the formulation of a sensitive space. *"With such a painting, we fool the eye, and so we present the rudiments required to outline it in roofs, rooms, vaults or arched surfaces"* [Vieira 1716: 270]. In essence, this table follows the *Liber Quintus* of Dechales' *Perspectivae*, introducing cases concerning the Portuguese practice *of quadratura*, circles of influence and authors.

Vieira exposes the *universal principle for delineation of any appearances in ceilings* (fol. 281) operating the passage from *vertical painting to horizontal* (fol. 281), to which is applied *"… a repetition of the already taken precepts… from which all appearances raised upon any sort of roof will be painted following the same method applied to vertical surfaces* …" [1716: 281]. The difference lies in the nature of the picture plane that can be flat, "… *circular, elliptical, or often consists of arranged planes and curves, forming an irregular surface on which it is very difficult and often impossible to find a bottom line, an horizontal line, and distance points, according to the universal practice…*" [1716: 283].

The *universal practice* mentioned consists of the image projection by means of grids laid over the architectural surface, allowing the transference of a delineated perspective. But, in Vieira's illustrations (as in Dechales' treatise), the deformation of the grid doesn't appear to be constrained to a specific point of view; it gives the impression of an orthogonal projection rather than a conical projection of the grid, as explained in the text. Vieira's manuscript doesn't address these inconsistencies between the explanation and the illustrations (figs. 290-291 of the manuscript), faithfully following Dechales' procedures for projecting the grid according to a specific point of view.

Exploring the construction of an underlying grid, Vieira proposes three possibilities for its projection onto irregular surfaces. "*For this, strings may be used… or by sight and nothing else, or at night by putting some light in the viewing point…*" [Vieira 1716: 283-284]. Besides construction through stretched strings or light rays, the author introduces a third hypothesis, "*by sight and nothing else*", referring to the accomplishment of perspective through trial and error based upon practical experience, while acknowledging that geometric-mathematical procedures would be implicit.

Through deformation of the underlying grid, it is possible to transfer *"… painted objects from each plain square (drawn in the prototype) to the corresponding projected quadrilateral, and we'll obtain the overall finished work*" [Vieira 1716: 284]. The grid's transposition from a drawn prototype to an architectural surface is explored by Vieira according to the vault's configuration and the composition of imaginary architectures, leading us to a new hypothesis on speculation over practical procedures of *quadratura*.

Fol. 292 shows a curved portion of a vault, ABCD, onto which it is intended to transfer an image previously drawn on a flat panel, CDFG, to be seen from the viewpoint E. According to the author, the use of light rays only occurs *"To better understand what is said…"* [Vieira 1716: 284]. They are used to demonstrate the grid's geometric transformations when it is projected from a flat surface onto a curved one. Simultaneously, the reference to the stretching of ropes increases the possibility of understanding geometric procedures through the materialization of abstract elements: *"… instead of the lines stretch out cords…"* [Vieira 1716: 284]. Meanwhile, Vieira identifies the basic geometric elements and their function: E - point of view, J - placed upright over E, which serves to divide the curved surface portion, ABCD, into quadrilaterals corresponding to the flat board, CDFG (figs. 9-10).

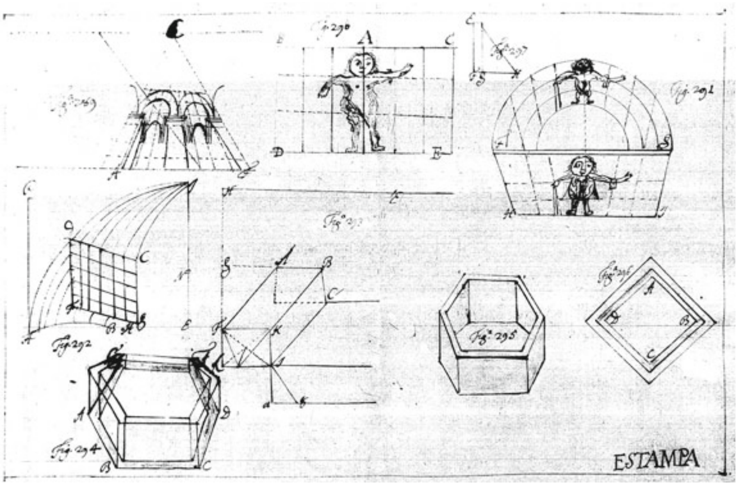

Fig. 9. Inácio Vieira, *Tractado de Prospetiva* (1716)

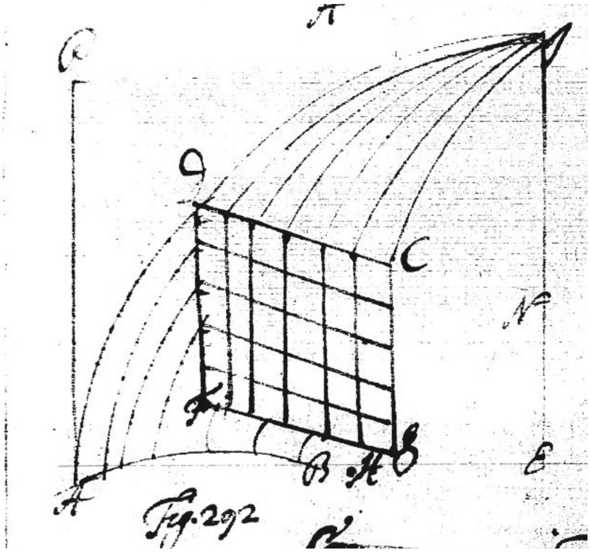

Fig. 10. Inácio Vieira, *Tractado de Prospetiva* (1716), detail fig. 292

The main problem of drawing architectural perspectives on curved surfaces concerns the transfer of grids, so that *"… irregular quadrilaterals formed on the architectural surface may appear to the eye equal to the squares of the panel CDFG"* [Vieira 1716: 284]. As such, this transposition and consequent deformation of the grid is organized in two steps concerning vertical and horizontal lines.

To project vertical lines CG and DF the author refers to Proposition 18 of Book 11 of Euclid's *Elements* [Vieira 1716: 285] (If a straight line be at right angles to any plane, all the planes through it will also be at right angles to the same plane [Euclid 1956: vol. III, 302]). Applying the Euclidian proposition, Vieira demonstrates that if CG and DF are vertical parallel lines to EJ, planes projecting these «shadow» lines, and containing EJ, are vertical surfaces: *"… where, by any of the identified lines and the sight E, an imagined plane will necessarily be vertical, through which shadow of the same line will be found…"* [Vieira 1716: 285]. As such, projection of the grid's vertical lines over the vault surface is determined by the vertical planes containing EJ as the projection of all intermediate parallel lines: *"…All vertical planes passing through the point of view E have the common section line EJ: so do all the shadows of the lines DF, FC, and the other parallel to this common point J"* [Vieira 1716: 285].

From this explanation, it may be inferred that it is possible that the projection of vertical lines was made either by calculation of the planes or by practical determination through triangulation by strings. It follows, at least hypothetically, that it is possible to drawn lines projection on the dome using only the space available between the scaffolds and the vault, without necessitating the unwieldy stretching of strings from the actual point of view located well below the surface on which spatial illusion was to be carried out. This hypothesis could pave the way for a consideration of an alternative practical procedure for the construction of an architectural perspective,[13] at least regarding semi-cylindrical or compound vaults resulting from the intersection of four semi-cylindrical with a flat central area.

The author goes on to say:

> *There is no difficulty, given three points of the same plane, EDJ, to extend the first string ED and, from the point J, extend another string that touches the first string at any given point so it will produce in the vault a point belonging to such plane – with this method we'll have the grid vertical lines* [Vieira 1716: 285].

As is usual with Vieira, the discussion starts with general rules and goes towards practical implementation, providing information for the accomplishment of perspective.

Regarding the projection of the grid's horizontal lines, Vieira says that once horizontal lines are equally spaced in the prototype, it is possible that to divide vertical line FD, used to obtain the grid's verticals lines, into equal parts (e.g., by knots tied on the rope itself) to obtain horizontal spacing: "… *a rope can be suspended from point D with its dividing knots, and we will have a quadrilateral corresponding with the prototype's squares*" [Vieira 1716: 285]. He continues the explanation stating that:

> *… each of the quadrilaterals obtained is the shadow of the matching square. So, they will arrive to the sight E by the same rays as the squares of*

the prototype: so painted objects in such quadrilaterals result in the same vision as in the prototype. The same method will be used when delineating an object on a vertical wall, but meant to be viewed obliquely in such a way that you cannot find the main point in it [Vieira 1716: 285-286].

The procedure set out by Vieira leads us, in the context of the practice of *quadratura* in Portugal, to the type of illusory architectural composition and the vaults on which *quadratura* is applied. The architectural composition is carried along the surface of the vault, above the surrounding moulding of the actual spatial box, until it reaches a constant height around a virtual perimeter. The level of that new virtual moulding may match the back of a vertical grid in DC, according to Vieira's scheme, leaving the vault's central section available for the depiction of an open sky, or providing space to install the *quadro riportato.* The grid's deformation, according to this assumption, can lead to the perspective discrepancies found in some *quadratura* paintings, through the use of "*sight and nothing else*". Moreover, with reference to the structure of real and illusory space in Lisbon's Menino Deus church (ca. 1730), might the four focal points (one for each side of the main composition) detected in previous studies, be a consequence of this procedure?

Let us now leave the practical implementation of these procedures and move forward in Vieira's perspective treatise.

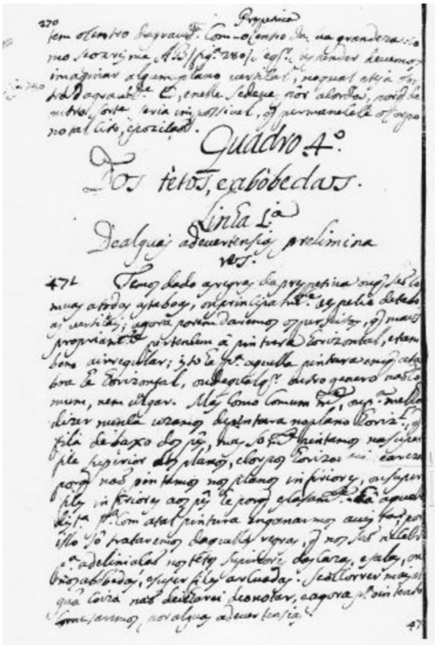
Quadro 4°
Dos tetos, e abobedas.
Lição 1ª
De alguãs advertencias preliminares.

Fig. 11. Inácio Vieira, *Tractado de Prospetiva* (1716), p. 270

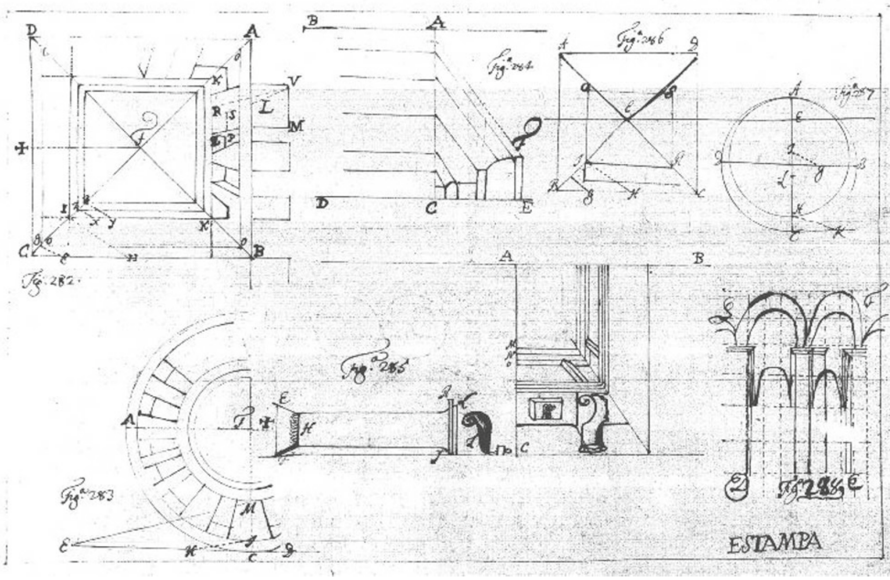

Fig. 12. Inácio Vieira, *Tractado de Prospetiva* (1716) no number

Spatial correction is introduced with "*The amendment of the bodies*" (fol. 289), in which the author addresses the "*Amendment of buildings*" (fol. 289), "*Amendment of the five-sided room*" (fol. 291), "*Amendment of the room with a inclined wall*" (fol. 292), "*Amendment of the very low ceiling*" (fol. 292), "*Amendment of sloped ceilings*" (fol. 293) and "*How to make a room, or porch seem bigger and outline a entire building, from which all the parts are seen*" (fol. 294). Vieira informs the audience at *Aula da Sphera* about how perspective can be orchestrated for spatial conceptions and the correction of architectural forms that interfere with the perception of built space. The process is essentially the application of an imaginary picture onto surfaces of the space so that, from a certain viewpoint, the desired simulation can be observed:

> *Every time a ceiling is very low and we want it, from a certain point, to appear higher, we must delineate a higher ceiling and continue its walls with false windows … When ceilings are sloped, it follows that one of the walls is higher than the other and the side walls will gradually deviate from equality. To amend this defect, the missing parts of the walls that lack equality must be outlined on the sloping roof…* [Vieira 1716: 292 - 293].

This application leads us towards the correction of physical space and the dramatization of reality based upon the illusion of the senses and therefore of reason. After defining perspective drawing, the author adds a deep appreciation of fostering depth based upon line and colour definition, amplifying illusion according to the precepts of atmospheric perspective. In this case, Vieira refers to his own sensitive experience in front of Bacharelli's work in Lisbon, "*… after I saw that feast of sunlight in St. Vicente's entrance hall quadratura painting, it doesn't seem so impossible for anyone possessing good art*" [Vieira 1716: 294].

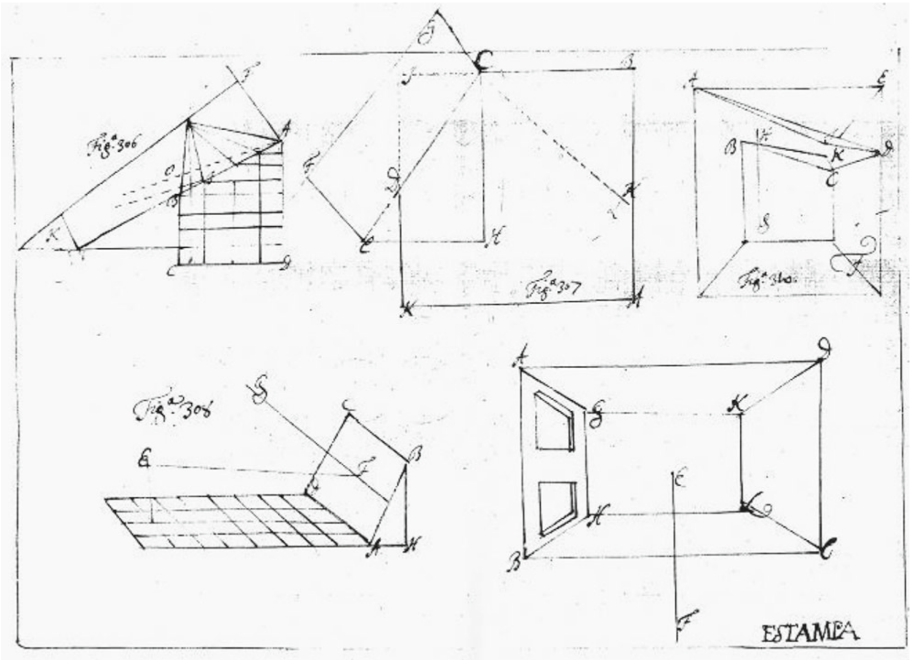

Fig. 13. Inácio Vieira, *Tractado de Prospetiva* (1716) no number

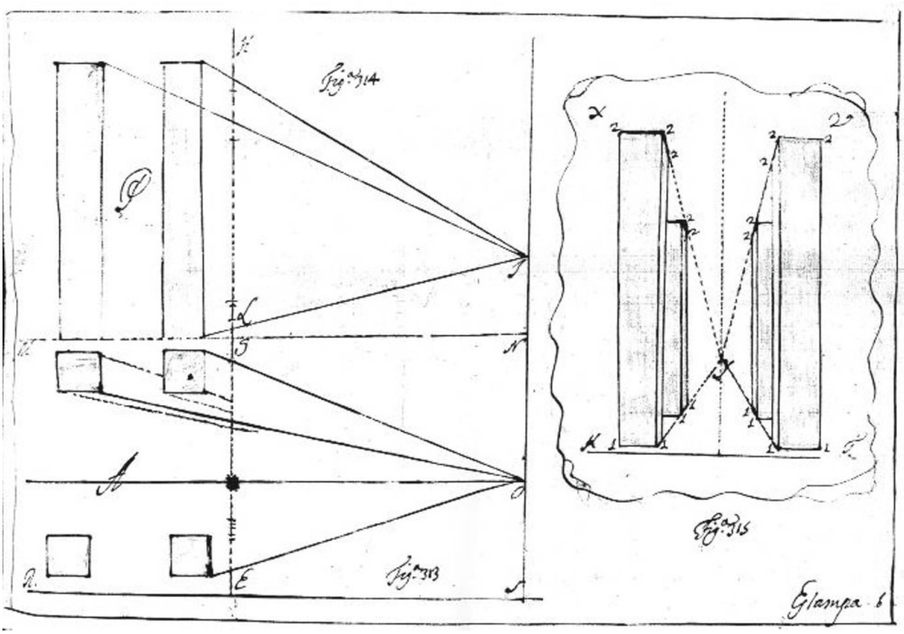

Fig. 14. Inácio Vieira, *Tractado de Prospetiva* (1716) no number

In the fifth table, "*Composition of various boards, reflection and shadows*", Vieira presents "*some more praxis from Brother Pozzo*" (fol. 296), setting forth other applications of perspective as tools to achieve a sensitive space: ephemeral devices and scenography. Pozzo's procedures are presented as resulting from his personal practice on painting, architecture and scenography, rather than abstract speculation, associating his construction process to the *costruzione legittima*. However, this system is more complex than the previously presented synthesis based on convergence and distance points. The same process of exchange occurs between Pozzo's Book I and II, where drawing is controlled with the aid of strings to determine the visual cone section. "*Instead of drawing lines with a pencil … we should apply to the view a thin string, or a drawing scale*" [Vieira 1716: 303]. This drawing process brings us to the perspective practical technique applied in image projection onto an architectural surface: ropes are extended from a specific point to the surface, transferring the desired prototype (fig. 14).

At the end of the treatise Vieira presents the pantograph, "*a useful tool for practice*" (fol. 333), explained in three chapters: "*Construction of the instrument to delineate*" (fol. 333); "*Perfect conformation of parts of the aforesaid instrument*" (fol. 340) and "*Use of this instrument*" (fol. 354). Christoph Scheiner's work, *Pantographice seu ars delineandi* (1631), is quoted at length, and Vieira praises this instrument whose function is "… *to design and launch on any surface any object's image… with infallible art* …" [Vieira 1716: 357]. From this statement we are obliged to ask: Can the pantograph serve *quadratura*? Can the instrument be used to transpose images from a prototype onto full-scale panels?

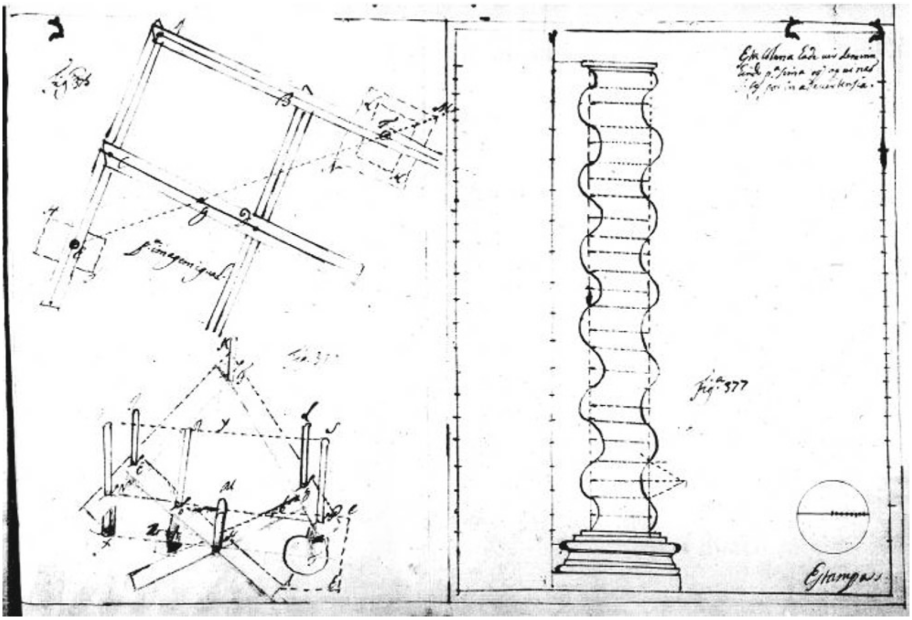

Fig. 15. Inácio Vieira, *Tractado de Prospetiva* (1716) no number

To the pantograph and the *mezoptico* instrument, we must add another projective device: the magic lantern described in Vieira's treatise on catoptrics (1717). There, in "*Appendix 1st*" (fol. 681), "*The Magic Lantern*" (fol. 681), "*From air, sun, and other appearances*" (fol. 685) and "*Method for making glass*" (fol. 689), the device displayed in

Lyon by a Danish scholar and seen by Dechales is revealed. According to the source, Vieira describes the relationship observed between the scale of the projected image and the distance to the wall, or screen, which may be adjusted so that "*… the height of the image equals the size of a man*" [Vieira 1717: 682].

Contrary to what is found in Kircher's and Dechales' iconography of the magic lantern, Vieira does not suggest a specific application of the apparatus, leaving this to his readers: "*From observation of these instruments a universal manufacture and use are taken … and as I write to ingenious masters, they alone can work out the truth of this manufacture…"* [Vieira 1717: 683]. However, he admits that all the arguments relative to this *machina* derive from the same principles set forth above in optics, perspective and catoptrics.

The visible world and construction of an illusory reality

Inácio Vieira's treatises evidence an extended reflection on optics and perspective to support image distortion and answer the formulation of a sensitive space, imaginary architectures at the service of the triumphant Church and Counter-Reform rhetoric. As Vieira writes, in his treatise on catoptrics, *"God our lord laid our intentions to his own greater honour and glory"* [Vieira 1717: 2].

During the seventeenth and eighteenth centuries, discussions regarding visualization and appearance were situated in the context of contributions from optics and perspective along with political and religious constraints that govern Counter-Reform imagery and spatial frameworks. As Kemp mentions, "The demands of the catholic reformers brought a renewed insistence on theological ends over and above the artistic means" [Kemp 1990: 85]. Theological boundaries were imposed on artistic and scientific issues, inducing a clear confrontation between Idea and Science: the idea of post-Tridentine doctrine based in Aristotelian space versus the scientific approach to a uniform and infinite space.

These contradictions are at the origin of a conflict between a symbolic vision and a mechanic vision of the world (resulting from Cartesian modernity and the scientific revolution). This conflict legitimizes the emergence of perspective understood simultaneously as a cognitive model, validating a scientific representation of the world, and as a symbolic configuration maintaining the Aristotelian approach of senses over knowledge: "During the seventeenth century, the space occupied by man was not homogenized, and the primacy of perception as the foundation of truth was hardly affected by the implications of this new science and philosophy" [Perez-Gomez and Pelletier 1992: 28].

Compared to the Renaissance, the Baroque provides the transition from symbol to allegory [Argan 1989: 7]. As such, the seventeenth century faces the passage from "imagined" – the Renaissance conception of an ideal world – to "imagination" – the vision of the world as an entity floating between reality and wonder. The symbol, mark of cognitive rationalization based on code and inducing significance of the Renaissance sciences, is replaced by the allegory, which establishes ambiguous references incorporated into Counter-Reform culture, placing the subject between reality and the sublime.

Baroque culture lies in infinite possibilities of connection between spirit and science. Spatial design in this period magnifies new aesthetic criteria integrating in constructive material a synthesis between science and theology: the mathematical-geometric abstractions of the design with the cosmic conception of a triumphant Church.

Within the spirit of these paradoxes is *quadratura,* transposing architecture representation from a two-dimensional picture into a three-dimensional simulacrum, together with metric spatial properties, and contributing to a transmutation of its perception. The space represented in *quadratura* is freed from the constraints of physical construction, and, in the fusion between reality and appearance, sets up a single entity globalizing physical and represented construction into a new appearance offered to perception. Space is replaced by its image, decomposed and recomposed in a dreamlike atmosphere where architecture, real and represented, appears as a spectrum mesh of lines and colours to be lost again in that whirlwind.

As a space and cosmos allegory, *quadratura* constitutes an extension beyond the data provided by building measure. This presents us with a space based on sensory experience triggering an experience of architecture that is perceptive rather than rational. With the achievement of imagination into visual image, the imaginary becomes part of reality. According to the embodiment of illusory images, it can be declared "… that to perceive something is not only to register it mentally, but to be solicited by it; the mind must create new systems of reference adapted to the perception of objects which are no longer 'natural', but artificial products of man" [Argan 1989: 55].

As such, the production of the Baroque image is not centred on the object but extended beyond it. As far as the architectural space is concerned, perception is led from the building's spatial constraints towards an image of unlimited space. The grandeur and monumentality of architecture isn't just a result of built form, but of simulated architecture, where *quadratura* generates a second, unreal nature, which in its likeness is indistinguishable from reality. Space, more than limited, is considered elastic as the perception of simulated architecture, referring the observer to a space whose proportions are variable, expanding it and taking away its uniformity.

Conclusion

Portuguese architectural production in the seventeenth and eighteenth centuries underwent a renewal through the assimilation of international models, including a new feature of spatial research: *quadratura* painting. The *contrappunto* of architecture/*quadratura* is intended as an action in which real (constructed) and illusory (represented) space intertwine, creating a complex reality.

The simulated of *quadratura* space constitutes a challenge to perception, generating new dimensions in architecture. This establishment of a new vision of the world results from the interaction of mathematics, optics and geometry, which can't be reduced to the construction of a physical and tectonic reality, but must include an apparent reality based upon the power of the projective image. The polyphonic nature of the Baroque is determined not only by the built formal exuberance but also by the participation of different arts and sciences in the conception of a global space.

In Portugal, the operative enunciation towards a full theoretical understanding of the subject applied to the configuration of a sensitive space taken by Inácio Vieira constitutes a seed that, along with the work of João Antunes (a definitive reference of architectural renovation, introducing models from international baroque adjusted to a national constructive tradition), simultaneously with the practical essays of the Florentine quadraturist Bacharelli in Lisbon (introducing and updating Baroque *quadratura* painting) paved the way for new developments in space conception.

In this context, the architectural project, along with *quadratura,* questions new dimensions on Portuguese Baroque space. The plurality of visual centres involves the viewer in a fluid space where seductive potential of the Baroque is accentuated by the integration of optical phenomena guiding space towards a new sensitive and illusory experience.

Notes

1. The term *quadratura* was established in the sixteenth century to describe the development of pictorial representation of illusory architectural environments, especially in illusionistic ceiling painting. It exploits knowledge of perspective and optics in order to deceive the eye, simulating a sense of depth and space.
2. The *Ratio Studiorum* was a regulatory document addressed to Jesuit teachers, promulgated in 1599, concerning the nature, extension and obligations over the curricula in order to unify pedagogical procedures among colleges of the Company.
3. Subjects ranged from astronomy to cosmography, geometry based on the study of Euclid's *Elements*, to arithmetic, algebra, plane and spherical trigonometry, issues applied to navigation, hydrography and cartography, optics, perspective and scenography, gnomonics, statics and hydrostatics, architecture and military engineering and other related topics, such as pyrotechnics and ballistics, etc.
4. Vieira's other treatises include Chiromancer – 17?? (BN Cod 7782); Astrology (ANTT ML 2122) and Chiromancy – 1712 (BN Cod 4324), both collected in M.L. 2132 from the Arquivo Nacional da Torre do Tombo (ANTT); Astronomy – 1709 (BN Cod. 2111), Astronomy – 1710 (ANTT ML 2044); Mathematical Pyrotechnics – 1705 (BN MSS. 22), Catoptrics – 1716 (BN Cod 5165/1); Dioptric – 1717 (BN Codex 5165/2); and Hydrographical or art of sailing – 1712? (BN Cod 5171), and also orientation of thesis: *Perspectiva Mathematica*, by José Sanches da Silva (1716) and *Conclusoens mathematicas de huma, e outra esfera e Architectura Militar Munitoria, e expugnatoria,* by António Gomes de Faro (1710).
5. In spite of some sixteenth and seventeenth century instances, one can say that Baroque *quadratura* was introduced in Portugal with the work of Vincenzo Bacharelli (1672-1739). This Florentine painter stayed in Lisbon from 1702 to 1719 and brought the updated model of the Bolognese School to Portugal. He painting the ceiling of the lobby in the St. Vicente monastery during this period (1710).
6. The dynamics of *Aula da Sphera* is revealed, in addition to teaching and scientific publication, by the organization of activities (the creation of ephemeral apparatuses for religious festivals or theatrical performances) that enables practical implementation of taught theories.
7. In this regard other manuscripts (BN codex 1869, codex 2127, Codex 2258, Codex 4246) must be taken into account. These are compilations of notes, which circulated among students and proved to be an important source of transmitted contents.
8. *Tractatus* XVIII; *Opticae – Liber Secundus*; *PROPOSITIO LXIX – Tesselatus, imagines consirvere*. The explored principle coincides with paragraph 94 of Vignola/Danti treatise, "*Come si faccino quelle pitture, che dall'occhio non possono esser viste se non riflesse allo specchio*".
9. *Tractatus* XVIII; *Opticae – Liber Secundus; PROPOSITO LXX – In plana superfície, imaginem difformem d'lineares qua ex certo & determinato loco, omnibus futs partibus absoluta videatrur.*
10. *Mezoptico* was the term used by Inácio Vieira to describe the device for drawing and projective designed by Athanasius Kircher.
11. As expressed at *Figura Prima* of book I of Pozzo's treatise, "*Explicatio linearum Plani & Horizontis, ac Punctorum Oculi & Distantiae*".
12. Pozzo, *Figura Secunda – Modus delineandi optice Quadratum*; Dechales, *Proposito I – Quadratum directe oppositum describere.*
13. This is an alternative procedure to the hypotheses presented by Daniele Di Marzio regarding the architectural perspective in the curved vault of Sala Clementina in the Vatican palace [Di Marzio 1999: 163-166].

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