HERMANN MAERTENS' *DER OPTISCHE-MAASSSTAB* AND THE PHOTOGRAPHY OF ARCHITECTURE

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HERMANN MAERTENS
OPTICAL SCALE
EARLY PHOTOGRAPHY OF ARCHITECTURE

The work of the German architect Hermann Eduard Maertens (1823-1898), and in particular his research on the *Optische-Maassstab*, results in a scientific, geometric tool, which was largely considered by urban planners and designers in the 20th century, to link the physiology of vision to the visual harmony of architecture. Based on the concept that distancing is an implicit, unaware consequence of beholder's specific visual intents, the Optical Scale proposes a triad of angles, to be measured on the vertical plane, through which analyzing or designing become a function of sight. The authors conjecture that some of the arbitrary features of his tool may be attributed to a specific interest in early results of photography of architecture as, although Maertens apparently ignored it, both his approach and photographs share a direct derivation from the tradition of architectural representation.

INTRODUCTION

The work of the German architect Hermann Eduard Maertens (1823-1898) in the 1870s and 1880s, and in particular his research on the *Optische-Maassstab* [The Optical Scale], is located in an area shared by different artistic and scientific disciplines which were evolving rapidly. Gottfried Semper, in his *Der Stil* (1860-63), has already linked the three dimensions of aesthetic perception –height, width and depth– to the human body, as synonymous with symmetry, proportion and direction, while Robert Vischer is introducing the concept of *Einfühlung* or Empathy in *Über das optische Formgefühl: ein Beitrag zur Ästhetik* (1873). The research on the physiology of the eye by Hermann Helmholtz (1821-1894), already published in the treatise *Handbuch der Physiologischen Optik* (1856-1867), provides fundamental and innovative information on the mechanism of human vision, underlining that the human eye sees in detail only a small fraction of the general visual field, eventually establishing the optical resolution of the pupil or the ability to distinguish an empty space between two signs. Franciscus Donders (1818-1889), inventor, together with Hermann Snellen (1834-1908), of the optotypes that still hang on opticians' walls today, statistically defines the "sharpness of vision" through the relationship between the result of the subject and the average result of the population. The very notion of the limit of the representable that establishes what to draw and what to exclude at the different scales of architectural representation derives from those observations.

Maertens takes possession of these and other approaches and outcomes and undertakes to define a geometric tool through which one can design and produce artifacts and buildings in relationship with the perceptual conditions imposed by the context and, vice versa, one can design and size the space in order to allow the optimal perceptive conditions of a given work or building. In particular, he establishes a triad of visual angles on the vertical plane from the horizon line upwards, which serve to place elements and walls in space

as a function of a vision of the surroundings, of an overall vision or of a detailed vision, according to a scheme that will have success and influence on the theory and practice of 20th century architects and urban planners. The optical and mathematical derivation of these angles as well as their symbolic intention, briefly presented here, seem to have a direct relationship both with the perspective inherited from academic studies, and with architectural photography, which in those years was spreading as an architectural and urban documentation tool. As a first part of an ongoing research, the authors focus here on the influence early photographs may have exerted on the work of Maertens, postponing the study of the influence that Maertens' ideas may have exerted on photographer themselves to a next occasion.

FROM THE CAMERA OBSCURA TO THE CHEMICAL CAMERA

The first system built in the Middle Ages to capture 'images' of visible reality is the *camera obscura*, a box in which a pinhole is made on one of the faces. What is exposed on the outside is projected inside on the opposite face to the one with the hole. If a dark room is used instead of a box, on the wall opposite the hole one can appreciate the 'projection' of the outside world, even if upside down; to remedy this, it is sufficient to insert a mirror, as can be still today experienced in the 19th device in the Rocca S. Vitale, Fontanellato.

Between the mid-14th and the following century, Optics and Perspective developed as two apparently distant fields of study that slowly contributed to perfecting this instrument. While the *camera obscura* was found to be the best model to explain the principles of perspective, eventually the picture determined by the pinhole was defined but not very bright. Therefore, some scholars of optics (Barbaro, 1569) began to place large converging lens (positive) on the small hole, in order to increase the brightness without losing definition in the projection. A century later, the *camera obscura*,

which had become an optical camera, was an aid to anyone involved in the production of pictures, primarily painters. Two types of camera were developed, with either external or internal projection. The former was the prototype of the classic photographic camera, with frosted glass in place of the surface where the image is formed, thus allowing the image in the 'box' to be viewed from the outside. A 45° mirror facilitated viewing from above, with a black cloth to obscure the external light. The image, which appeared straight (top/bottom) but mirrored right/left, could be recorded with ink, pen, transparent paper –generally a sheet of paper made translucent with wax or oil– and patience.

The internal projection camera was instead composed of a structure with an objective placed vertically on the upper face and an external mirror disposed at 45°. In a more functional way than the former type, the projection took place on a horizontal plane, onto which one could place a notebook and 'transcribe' the rectified image. This practice is exampled by the *scaraboti* made by Van Wittel or Canaletto between the end of the 17th century and the beginning of the 18th. Canaletto's 'manual photographs' reveal also that the painter used several lenses depending on the distance of the urban sector he wanted to capture, with horizontal angles ranging from 20° to 30° and therefore with a greater vertical amplitude (from 30° at 45°). Those were objectives that today one would define medium telephoto and normal.

The construction of first optical camera, capable of imprinting the image automatically on a stable support, required to develop and experiment with light-sensitive substances –first the 'bitumen of Judea' and then the 'nitrate of silver'– laid on a rigid surface inside the camera and exposed to the light through the objective. Between 1820s and 1830s, Joseph Nicéphore Niépce and Louis Daguerre pioneered this form of automatic image recording. But the fundamental concept that generated the impetus for the great development of chemical photography was the technique of the negative and the consequent printing, which implied also the

idea of an unlimited reproducibility. William Henry Fox Talbot fulfilled this goal together with his friend John Hershel, thus defining the procedure of the calotype, which can be appreciated in *The Pencil of Nature*, an illustrated book with real prints glued one by one (Talbot, 1844-1846).

In the 1870s, when Maertens began publishing his studies, photography was already a popular technique that was fully integrated into the mass market. It was still used by painters as a support to their work but was acquiring the dignity of a tool capable of documenting reality, and architecture, in an apparently objective way. The most common cameras were the comfortable and transportable folding cameras, with different sizes and able to perform one image at a time on a glass plate (and, shortly thereafter, also on film). Thanks to the ease of use and flexibility of these devices, until the following century there was no need to expand the range of objectives, even if the technologies allowed to increase the focal length especially towards telephoto lenses, which are easier to build and without drops in quality compared to normal optics. Wide-angle lenses, on the other hand, involved difficult optical schemes that always involved problems of distortion and aberration of the image at the edges.

MAERTENS' *DER OPTISCHE-MAASSSTAB*

In 1877, Maertens published the first edition of *Der Optische-Maassstab or Die Theorie und Praxis des ästhetischen Sehens in den bildenden in the Auf Grund der Lehre der physiologischen Optik*. The book, whose cover shows a curious section-diagram with three men looking at a monument (Figure 1), is addressed to a wide range of professionals: "Architekten, Maler, Bildhauer, Musterzeichner, Modelleure, Stukkateure, Möbelfabrikanten, Landschaftsgärtner und Kunstfreunde" (Maertens, 1877, frontispiece). Indeed, his work had a great influence in the following decades, especially on German town planners, such as Josef Stübben (1893), Albert Erich

Fig. 1 Hermann Maertens, *Der Optische-Maassstab*, Cover of the second edition (Maertens, 1884).

Brinckmann (1914), and Werner Hegemann (Hegemann & Peets, 1922), who had the merit of exporting these ideas to America. In general, he contributed to forming the discipline of 'Visual Planning' (Cepl, 2012). Architects, on the other hand, were educated to Maertens' ideas in an almost subliminal, unconscious way, thanks to the famous Ernst Neufert's *Bau-entwurfslehre*, which, from 1936 onwards, redesigned and re-assembled his most efficient diagrams in the pages dedicated to visual perception.

The book presents an elaborated system of optical proportions as an attempt to provide artists, architects and graphic designers with a scientific, deterministic tool and even to translate the secret formal relationships of archi-

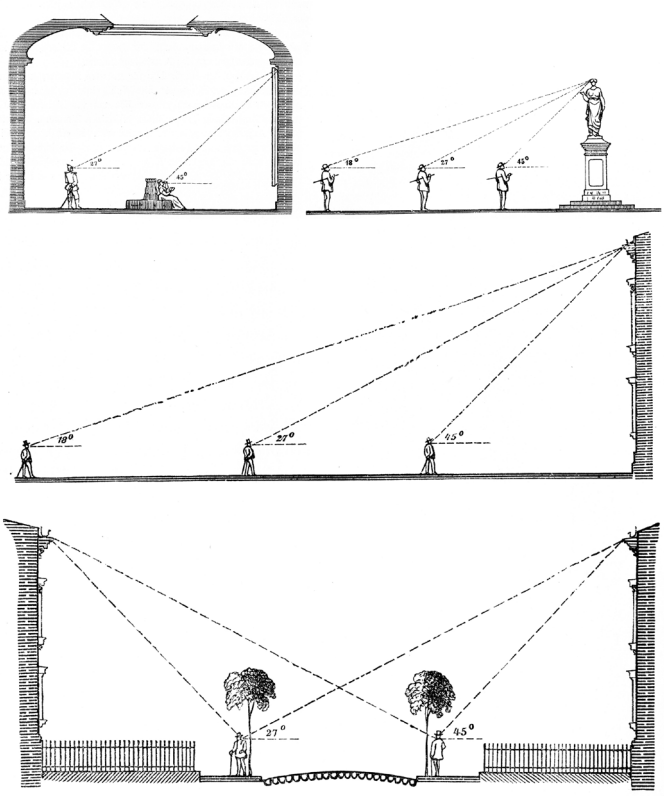

Fig. 2 Hermann Maertens, *Der Optische-Maassstab,* Maertens' diagram of triad of angles. The 18, 27, and 45 degrees visual angles in the contemplation of pictures in a gallery, of a monument in a garden, of the facade of a building, and in designing a street section (Maertens, 1884).

tectural spaces into easy geometric ratios (Colonnese, 2017; Carpiceci & Colonnese, 2017, 2018). Starting from the eye resolution, Maertens individuated some readability parameters –the body should be 1/3450 of the widest distance of reading (Maertens, 1884, p. 4)– which could be used to size correctly both the letters onto a street sign or page of a book, and triglyphs or dentils on the top of a cathedral. Then he explained that the act of distancing from a building or an artwork is strictly connected to the kind of vision pursued by the beholder. Finally, he formalized such a formula in a triad of visual angles that set distances and thresholds for three different ways of contemplating architecture (Figure 2). When seen under an 18° wide angle of field, a building appears to be part of the surrounding context around it as a whole image; under a visual angle of 27°, it appears in its integrity and completeness; under an angle of 45° or more, details conquer

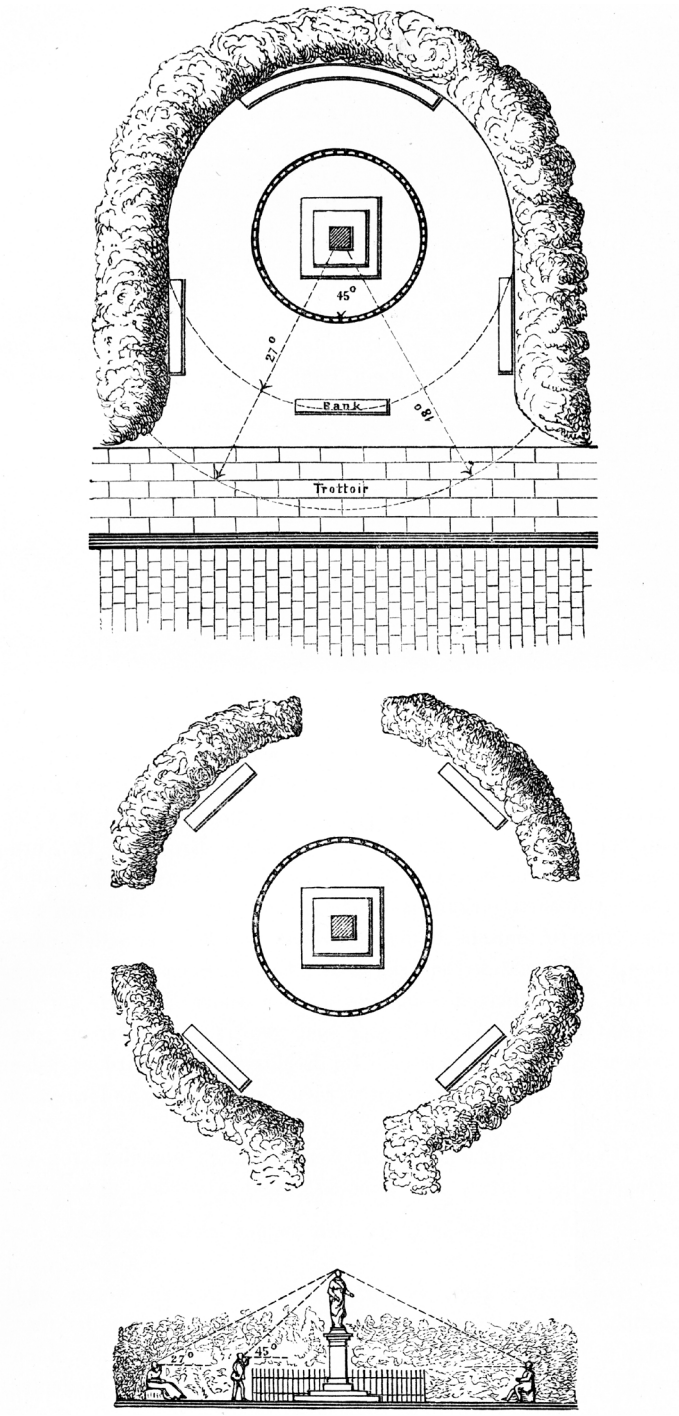

Fig. 3 Hermann Maertens, *Der Optische-Maassstab,* Maertens' design of a garden around a monument through the application of 18, 27 and 45 degrees visual angles (Maertens, 1884).

most of the observer's attention. In this way, the 'correct' vision can be turned into a designing tool to size squares, streets, halls, rooms and even commercial signs.

By way of explanation, Maertens applied this formula to design a small garden and define the different areas starting from a monument placed upon a plinth in the center (Figure 3). The location of the protective fence of the monument is established by the distance corresponding to a vertical visual angle of 45°; the position of the crown of surrounding flower beds is established by the distance corresponding to a vertical visual angle of 27°; the position of the perimeter path is finally established by the distance corresponding to a vertical viewing angle of 18°. In this way, he demonstrates how to apply his Optical Scale to design public space providing people the opportunity to see the monument in contextualized vision from the path, in a general vision from the flower beds and in a vision of detail from the fence around it.

Parallel to this kind of applications to different design fields, he proposed very accurate investigations on ancient and Renaissance monuments and squares, with tables full of numeric data attached at the end of the volume. As a descendant of the Renaissance perspective tradition, he was questioning about the actual impact of proportional rules onto the visual effect. In this way, Maertens moves simultaneously on both the level of historical studies, providing art historians with a scientific tool for an aesthetic judgment, and on that of design and urban planning, providing designers with a tool for dimensioning spaces and buildings according to human visual performance.

Maertens' triad of angles arises from the fundamental ratios of 1:3, 1:2 and 1:1, but the choice to approximate the first two angular results at 18 and 27 degrees is an arbitrarily pondered choice. 45 is the sum of 18 and 27 and the three numbers are in a ratio of 2:3:5 to each other, having 9 as a common denominator. The choice of these specific numbers seems aimed at presenting a formula both of universal value and easy to remember. There is also a fourth ratio, equal to 1:6 or

72°, which marks the threshold of the panoramic vision but is almost never used.

In addition to these small approximations, which can be defined as 'poetic licenses', there are also choices that appear arbitrary and that deserve a further study. First, Maertens almost ignored the width of the buildings –or their extension on the horizontal plane –to focus exclusively on their height; secondly, he considered the ideal visual framework as invariably vertical and the optical axis as horizontal, assuming the ground under the feet is always horizontal and the gaze remains constant; finally, he neglected the opening of the visual field below the horizon, as if it were a variable that cannot affect the final outcome of the application of his optical scale. Photography can help us understand partially these choices.

CONSIDERATIONS

Since the beginning, the early photographers have oriented their primitive cameras towards landscape and architecture. Being inert subjects, these were compatible both with the light conditions necessary to impress the plates, and with the times of the long exposures the cameras required. Fox Talbot himself, already in the summer of 1835, had dedicated himself to picturing his house in the countryside with different light conditions and was the author of splendid photographs of monumental buildings already in the early 40s.

The early photographers, who have in their hands a new tool with which to represent the world, first of all confronted themselves with the existing images, trying to reproduce the results of the artists. While the first architectural subjects were chosen above all on the basis of their accessibility, lighting and the possibility of framing them in the visual field of the machine, the visual models adopted are above all those made available by the visual arts, such as drawings, engravings or paintings (Ackerman, 2001). In this sense, the image of buildings remains rigorously vertical for years, as

suggested by the practice of orthogonal projections and perspective views in design and commercial representations. In the work of the Frenchman Henri Le Secq (1818-1882), active as early as 1848, one can appreciate the closeness between his photographic images and the canonical perspective representation with a vertical picture-plane, almost exclusively central and rarely accidental. Furthermore, such images exhibit the real proportions between the parts and can be easily interrogated to obtain metric data. By the half of 19th century, this type of photography appears suitable for the first documentation of the monumental heritage, a task to which Le Secq and dozens of other photographers are called in countries such as France and England. In this initial comparison with the canons of architectural design (De Rosa, Sgrosso, & Giordano, 2001), photographers often look for elevated points of view in the surrounding buildings in order to preserve the optical axis horizontal.

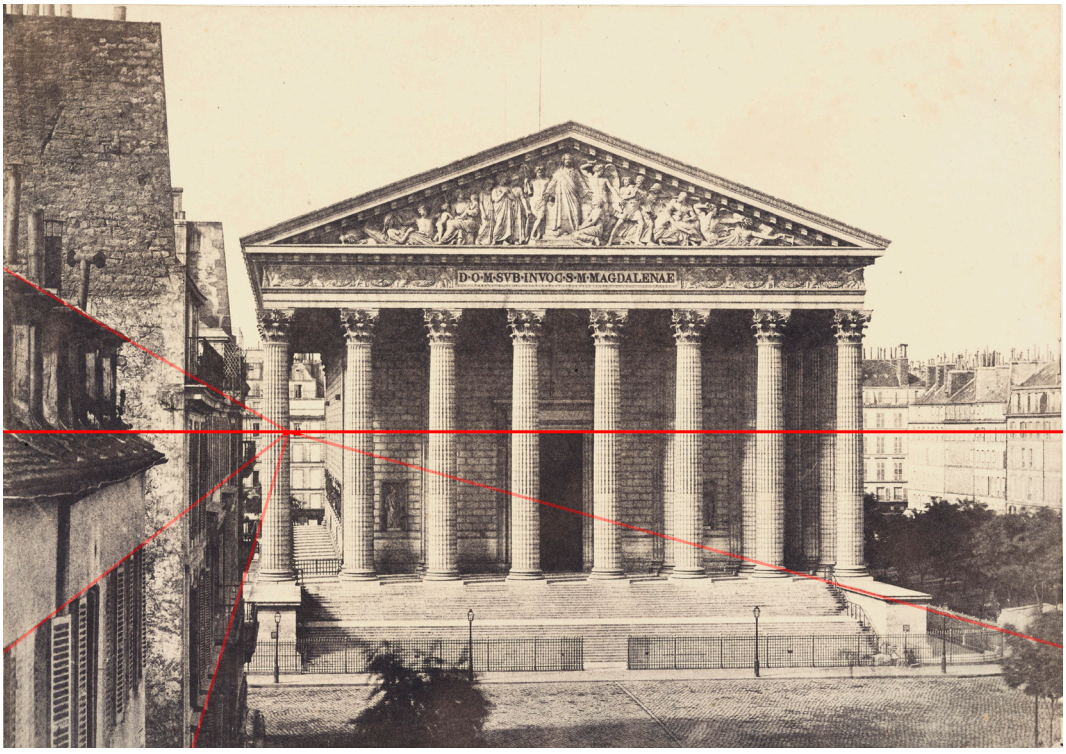

Fig. 4 Henri Le Secq, Louis Désiré Blanquart-Evrard, Church of the Madeleine, 1851-1853. The Getty Center, 38422 (Public domain). The horizon line demonstrates Le Secq was at a window on the third floor trying to keep the objective as parallel as possible to façade (graphic elaboration by F. Colonnese, 2020).

This approach, testified for example by Le Secq's photo of La Madeleine, Paris (Figure 4), responds to the needs not only of the lens and framing but also to the opportunity to avoid obstacles or disturbing elements at the ground floor and to present a clean, intelligible facade, such as those produced by the draftsmen or delineators (who, however, only need a stroke of the rubber to solve the problem). By raising the point of view, photographers are also able to make the most of the camera's field of view, solving a problem that appears evident in a picture of Piazza del Popolo in Rome shot in the late 1860s (Figure 5). Assuming that the anonymous Italian photographer was using a normal objective, with a 47° wide field-of-view, the camera was probably placed under the porch of the church of the S. Maria dei Miracoli, five steps above the level of the square. The axis was slightly inclined (about 2°) to catch the top of the obelisk. The photographer had to go far away to frame the gateway with the buildings on both sides. He sacrificed the entire lower half of the image (about 20° of the whole field), occupied by the pavement of the square and compressed the architecture only in the upper half (about 27°, one of the angles suggested by Maertens), most of buildings covered only by a 12° wide angle. Conversely, by raising the point of view or by cutting the lower part of the photograph, the image would be rebalanced and focused on the architectural subject.

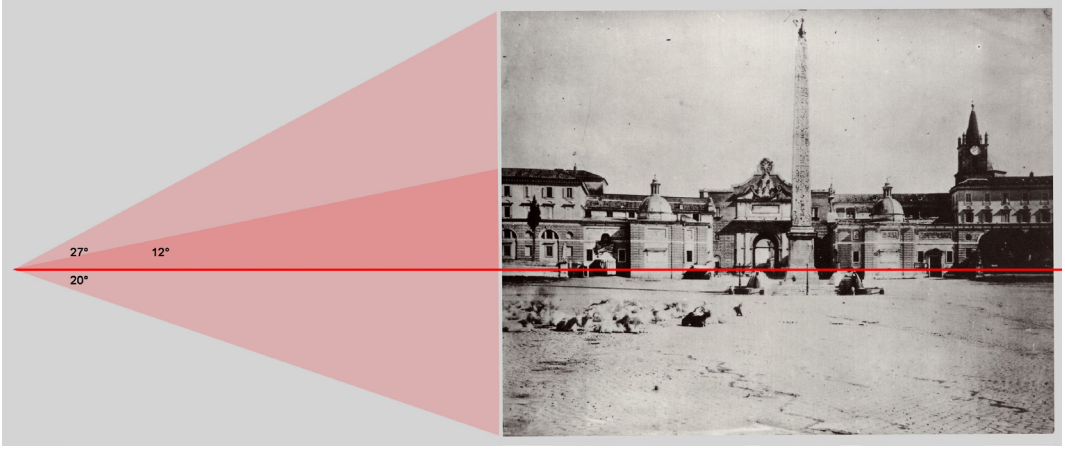

Fig. 5 Italian Anonymous Photographer, Piazza del Popolo, late 1860s (Public domain). On the left, the field-of-view of a supposed normal objective placed on the horizon line with the angles dedicated to the sections of the picture (graphic elaboration by F. Colonnese, 2020).

This problem seems strongly felt by Maertens, who constrains his vertical angles of 45°, 27° and 18° to the horizontal axis. First of all, one can deduce that the horizontal angle of view, which is physiologically wider, is less interesting because it is the vertical one that conditions the beholder's distance from the architectural subject. Added to this, one can deduce that the other half-angle not explicitly marked would be the other part of the visual field which, however, would include mostly the ground. Therefore, if one was to measure the complete angular amplitude of the three positions reported by Maertens, would have the corresponding angles of 90°, 54° and 36°. The angle corresponding to the 'normal' focal length is supposed to be identified in a size equal to the diagonal of the frame, that is the angular amplitude sufficient to 'cover' the entire sensitive surface (Carpiceci & Terrana, 2005; Carpiceci, 2012 pp. 56-60). This size is about 53°, corresponding to an area of the retina in which a beholder tends to place a target to be observed in its entirety. In practice, normal objectives are defined by an angle between 47° and 63°. For smaller angles, one has telephoto lenses, which allow to analyze an increasingly restricted part of the subject. The larger angles, typical of wide-angle lenses, instead broaden the immersive effect by embracing the context. Thus, somehow, the very formulation of the Optical Scale in three viewing angles suggests a direct parallel with the normal, telescopic and wide-angle vision induced by photography.

DISCUSSION

Hermann Maertens' *Optische-Maassstab* constitutes one of the first scientific-based tools capable of linking human visual perception and the geometric characteristics of space and, consequently, to analyse human behaviour, in particular the instinctive distancing and aesthetic judgment in an innovative way. Maertens was persuaded that the first impression

of a work determines its aesthetic judgment and that this is the result of a basically fixed gaze, in which the role of normal or direct vision, which is extremely limited compared to the general visual field, is fundamental. In particular, he was seeking for a formula able to link the physiology of vision to the visual harmony and beauty of architecture and the choice of a simple triad of angles, addressed to both historians and designers, is the main reason of his long-lasting success.

The concepts expressed in his book stigmatize concepts of visual perception taken from Optics and Perspective but certainly does not ignore the results of the growing practice of Photography. Although Maertens apparently neglected the potential role of photography in proportioning and documenting urban spaces, both his approach and photography imply an observer standing still, are unable to describe the growing movement taking place in the cities and take into no account the role of colors. More analogies emerge when observing the early results of photography of architecture as well as the technology of early cameras and relating them with the geometric features of Maertens' Optical Scale.

The iconographic, geometric and perceptive observations here presented about the early photographs suggest that Maertens was at least stimulated by the observation of architectural photographs taken with points of view at different heights and different angles of view, which gave different sensations to the beholder precisely because the (architectural) subject possessed those perspective characteristics that allowed it to relocate space in a certain dimension. In particular, the choices of photographers, especially those engaged in a 'documentary' activity, to follow certain canons of architectural drawing, seem to encourage some of the arbitrary choices made in the formulation of his Optical Scale, such as the optical axis kept horizontal, a frontal relationship with the building, and the determining vertical angle starting upon the horizon plane. Somehow, in a sort of didactical approach, he seems intended to preserve the conditions that guarantee a result that can be comparable to traditional central perspective view, the architectural subject filling the whole sheet.

CONCLUSION

Photography, and its diffusion and application to architectural and urban subjects, offered artists and scientists the opportunity for a general reflection on human vision, which promoted the Impressionism as well as the Optical Scale. In this sense, centuries after the construction of the early *camera obscura*, the vision of photographers moving their cameras and tripods to find the best point of view to frame a gorgeous façade worked as a disruptive catalyst capable of suggesting the idea the human eye works as a machine and has a fundamental role in assuming positions and distances. In this sense, Maertens proposed a key to remediate the visual experience of famous buildings and squares according to vantage points and distances induced by his Optical Scale as well as to consider every single distance in an exclusive, optical key.

Today, the experience of moving, distancing and remediating the urban image while looking for a proficient framing is a daily –even hazardous, sometimes– experience shared by billions of people equipped with digital cameras and smart-phones. When somebody's life is reduced to a sequence of selfies to post on a social network as soon as possible, the urban space may be considered as just a collection of vantage points for photogenic pictures. Besides the excesses of the medialization and virtualization, this practice, which is increasingly felt as an inviolable expression of freedom, clatters against not only the intrinsic limits of objectives and physical obstacles but also cultural habits, as evidenced by Edward T. Hall's (1966) studies on proxemics, and behavioral rules, like privacy, private property or the social distancing currently needed to prevent the diffusion of Covid-19 plague. Thus, like the early photographers, bound to the mechanical limitations of their primitive cameras, today we happen to move along the lines of an invisible network of allowed positions, continually remediating distances we were accustomed to but unable to find the right distance to remediate our present in a single, clear picture.

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