Measuring the Immeasurable. Communicating Perspective-Based Painted Spaces to the Blind

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Abstract

This paper deals with the challenge of making perspective-based painted spaces tangible and accessible, and therefore measureable, by those who cannot rely on sight. Is it possible to do so by means of alternative channels? The answer to this question can be found in the tools of representation: the space obtained through the reversed procedure of linear perspective allows the creation of a three-dimensional model of such space that can be explored through touch. Architectures painted according to the principles of perspective have been historically translated into tactile language by resorting to the bas-relief. The research presents a reflection on such didactic device, suggesting the application of accelerated solid perspective to the restituted space. In this way, distortions and convergences resulting from the application of the rules of perspective can become tactically perceivable. An educational model based on the comparison between the three-dimensional model of the actual restituted space and the one deformed by solid perspective is thus proposed, presenting the painted architecture of the Feast of Herod *(ca 1462-65) by Benozzo Gozzoli as a case study. The multisensory approach represents an extremely inclusive strategy: indeed, the communicative-didactic apparatus based on the involvement of extra-visual senses must be imagined and conceived as accessible for a diverse audience. As a consequence, any user can add a surplus value to their own experience, changing their own yardstick regarding the work of art and discovering a new way to relate to it.*

Keywords: blindness, perspective, touch, multisensory communication, painted spaces.

Introduction

"Measure what is measurable, and make measurable what is not so". Galileo Galilei

We mainly rely on sight to "capture reality", to grasp its features, to analyze its details, to measure its components. The supremacy of sight over all other senses is centuries-old, especially when we need to relate to the complexity of images or to resort to the privileged means of studying the visible: drawing. Most of the art produced since the Renaissance is crossed by the hidden lines of perspective, which serves as its frame, its scaffolding and its supporting structure. For instance, the position of the vanishing point guides our gaze, establishing the prime location of the observer; in addition, the convergence of vanishing lines mimics the functioning of sight, chasing the axiom of visual realism. Perspective rules the composition while unifying time and space in a *continuum*. Perspective-based painted spaces are geometrically constructed, therefore they can be fully measured: it is consequently possible to translate them into three-dimensional models that can be explored through touch. Reflecting on the accessibility of perspective-based paintings by a visually impaired audience does not simply mean to design a mere compensatory measure addressed to a minority of users who cannot rely on sight. Being able to 'touch' the distortions resulting from the application of the rules of perspective can be rather seen as a chance of knowledge enrichment also to sighted users, who discover they can see more –and better– through a new, alternative way to experience the work

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of art. For centuries, the museum environment has been regarded as the "empire of sight" [Stewart 1999, p. 28] and as a place of contemplation, therefore we are not used to employ other senses in our relationship with art. Designing an educational model for the 'translation' of perspective into haptic language actually means to design an innovative way to experience artworks which fully embodies the spirit and the truest, most authentic meaning of inclusion. Inclusion intended as a process of re-arrangement and re-organization of the context that, triggered by the request of someone who is "outside", 'forces' those who are "inside" to re-negotiate lexicons, procedures, institutions. In the *17 Sustainable Development Goals* (or *Global Goals*) of the 2030 Agenda, inclusion of people with disabilities is often mentioned in relation to different issues, including the participation in cultural life and the fruition of cultural heritage. Dealing with a disability can be compared to art making: in both cases, community rules are subverted, repressive and paralyzing norms must be shaken and expressive means and cognitive processes are constantly reinvented, revealing the unpredictable fragility of the human condition.

From reality to its representation: blindness and perspective

Whether it happens through touch or sight, the aesthetic experience is "imaginative" [Dewey 1951, p. 128] and it consists of the mental image that each one of us creates on an intellectual level. Assuming that people with disabilities can live an aesthetic experience [1], the main issue to investigate is the relationship between perspective (or, more in general, projective geometry) and visual impairment. The debate over this problem is still open and controversial and, according to Mazzeo, there are two main psychological theories: the first one is the *visuo-amodal* theory, supported by John M. Kennedy, according to which there is a visual component in human perception of space which substantially cannot be eliminated, as if it was *a priori* category or an invariant of human species; the second one, the *synesthetic hypothesis*, believes instead that space can be acknowledged by blind people only through the remaining senses and in its volumetric and tri-dimensional nature [Mazzeo 2008, pp. 117-118]. The Canadian psychologist Kennedy claims that non-sighted people access perspectival representations basically just like sighted individuals do, as he observed in both early and late blind individuals' drawings the ability to reproduce features that are typical of visual perception, just like perspective, which depends on a viewpoint and on distance. According to the scholar "perspective is an ever-present influence on perception, tactual as well as visual, but how it operates is not always well understood" [Kennedy 1993, p. 180] and the most significant example he brings in support of his assumptions is the case of Esref Armagan, a congenitally blind Turkish painter whose artworks show the ability of mastering one-point and two-point perspective [Kennedy, Iuricevic, 2007]. It follows that also a congenitally blind person can comprehend and master the principles of perspective as a way to represent reality on a bidimensional support. However, it is also true that Armagan has practiced drawing for a long time, developing and refining his ability to understand and to reproduce features that belong to the functioning of sight. A blind user visiting a museum has hardly been trained to intuitively understand these spatial aspects, especially because, as de Rubertis points out, "non-visual thinking strongly refuses projective concepts, such as interposition and the apparent form of an object which changes depending on its position in relation to the viewer" [de Rubertis 2006, p. 7]. Therefore, a representation designed for an 'extemporaneous' fruition of a painting must be both educational and synthetic, as we cannot take for granted that a blind visitor has prior knowledge of perspective or that he has even practiced it. Consequently, the aim must be to make intelligible the scientific-geometric process, that, by imitating the functioning of sight, allows the transcription of a tridimensional space 'as we see it' on a bi-dimensional support, without assuming that a visually impaired user can intuitively understand and handle perspective projections. After all, even sighted people face difficulties when dealing with the transition from *perspectiva naturalis* to *perspectiva artificialis* on their own, even though they constantly experience the first one in their daily life. It is indeed remarkable that a discipline concerning operations that take place in a three-dimensional space can be explained and learned only through plane and bi-dimensional representations of spatial processes, to the point that this "is an obstacle also to sighted people, since that those who do not possess an innate sense of space find it difficult to handle images representing, in their projective distortions, the projective mechanisms causing the same distortions" [de Rubertis 2006, p. 7]. Geometrical-optical linear perspective can be understood only through a conscious cognitive process: it's a skill that must be learnt, like reading and writing, no matter how obvious the optical illusion of perspective convergence can be in the Western world, where it is generally considered the paradigm of pictorial realism. A 'scientific training' to linear perspective is instead necessary to acknowledge its value and correctness, as this does not depend uniquely on the physiology of vision and on rough data perceived through sight. In geometry education for blind people, it is widely known how to make spatial invariants such as parallelism and perpendicularity comprehensible [2]. Yet, what happens when such geometrical 'certainties' are questioned and measures are altered by perspective distortions? Just like pre-school children have not yet developed spatial categories to accurately interpret perspective-based representations, blind people lack the references to understand projective invariants, such as the concept of lines –which are parallel in real life– converging to one or more vanishing points in the perspective transposition. These concepts must be therefore conveyed on a different level by making them tactically perceptible through an educational effort which allows blind people to access a wide range of sensations that otherwise would be denied.

Seeing through hands: touch and its cognitive function

As a matter of fact, touch and speaking become the units of measurement of reality for visually impaired people, since they cannot rely on sight to interpret images. While touch decodes forms by means of haptic exploration, measuring their features and properties through a series of specific gestures, speaking –with its strong evocative and representative power– co-operates with the former, carefully avoiding to fall into deleterious literalism. Touch is thus the main compensatory sense for all visually impaired people (early-blind, late-blind and low vision subjects) and the only one which is able to recognize shapes. It is then necessary to recall the essential distinction between early and late blind individuals: early-blind subjects, who never had any visual experience or they only had it for a very limited time, are more adept at fully exploiting their tactile-manual system to interact with the external world. However, perception and representation of space are way harder for them compared to late-blind individuals, as they could not or barely benefit from visual images [Hatwell 2006, p. 79]. For blind people, learning how to efficiently use the remaining senses to acknowledge formal and spatial values is an essential training that echoes in the emotional and intellectual sphere. At the same time, empowering and expanding sensoriality reinforces the awareness of perceptive and cognitive abilities in sighted people, teaching them to see things more in-depth. *Hands-on* approaches are in-

Fig. 1. Herbert Bayer, Lonely Metropolitan, 1932, photomontage.

deed among the most efficient educational strategies, even for those who normally relate to art through sight: learning to explore objects with our hands teaches us how to organize the comprehension of the artwork starting from shapes, composition and perspective-based space to reveal its content and meaning. Touch can therefore "facilitate imitative decoding and add "feeling" to the visual experience" [Ruggeri 2006, p. 47], making possible to share linguistic, technical and semantic codes that enriches communication and integration between sighted and non-sighted people. Learning to 'see more' thanks to the analytical support of touch opens up to a reflection on the real potential of sight and on the power of the inner eye. Indeed, the depth of our gaze is measured from the capability to relate to the various aspects of intellectual and physical life, whose combination builds the perception of reality. It is thanks to this synergistic co-operation between senses and mind that every experience can be encoded and decoded, so that "sight means feeling and feeling means knowing" [Secchi 2010, p. 13]. If we do not practice 'feeling' by involving all of our senses in our relationship with reality, we risk to falsify vision itself. As Maddalena Mazzocut-Mis argues: "touch doesn't lie, hide or deceive but it creates instead a world on a human scale, without chimeras or false illusions. Images can lie, while the hand that touches and recognizes contours and borders does not. Images are a quick glance at the world, while touch slowly caresses things: touch is then the only true form of apprehension beyond the illusions of the senses" [Mazzocut-Mis 2002, p. 13].

Translating paintings into haptic language: the bas-reliefs from the Anteros Museum

In the case of paintings, a tactile fruition of the original artworks is, of course, impossible and the problem of accessibility for people with visual disabilities presents unquestionable difficulties. It is therefore necessary to resort to tactile representations and models to support the original artwork. Kennedy affirms that "not only can space can be represented in different ways; each way can be translated into another" [Kennedy 1993, p. 211]. Perspective bas-reliefs are currently the most employed devices to translate pictorial works into tactile language for blind people, in continuity with the tradition of Renaissance and Neo-classical bas-relief, originated during the XV-century in Florence. Differently from tactile diagrams, bas-reliefs are characterized by a greater resemblance and coherence compared to the bi-dimensional original artwork, since they respect its formal and compositional values, given that the original artwork itself suggests the idea of three-dimensionality. Tactile bas-reliefs are not merely copies of the original paintings but instead they "facilitate the perceptive and cognitive acquisition of concepts such as foreshortening, perspective space, space-time relationships between different elements, contour, volume, surface, expressive and aesthetic values of form" [Secchi 2004, p. 64]. Such features make it the most 'readable' and significant device for blind people, whose manufacturing process involves a complex and delicate 'translation' operation of bi-dimensional images into similar three-dimensional forms –which is essential for tactile exploration– currently carried out by skilled professional sculptors. The Anteros Museum in Bologna, directed by Loretta Secchi, creates refined perspective bas-reliefs resulting from a pioneering research project started in 1995, which gave a significant contribution to the development of museum educational services dedicated to visually impaired visitors. The collection is made of handcrafted tactile bas-relief transpositions of pictorial masterpieces, whose main feature is the undercut (*sottosquadro*), a technical device borrowed from traditional Renaissance bas-reliefs through which figures and volumes emerge from the background. The undercut simulates perspective planes receding towards the vanishing point, as if they were theatrical backdrops, building a bridge between sculpture and painting. The scale of a model is chosen according to the level of complexity of the painting and its tactile readability: dimensions can either correspond to the original ones or it is possible to use a larger or smaller scale, always taking into account tactile tolerance thresholds universally shared in the field of haptic perception and visual impairment [Secchi 2010]. In addition to the perspective bas-relief reproductions of famous paintings and copies of Renaissance reliefs, the Anteros Museum collection includes preparatory perspective boards (fig. 2), which try to unfold the projective operations for the creation of perspectival images to a visually impaired audience. Indeed, perspective construction lines are in relief and tangible: they inscribe the figures in order to highlight the convergence of parallel lines towards the vanishing point located on the horizon line. This eventually explains the alteration of perspective forms compared to the actual figures located below the ground line [3].

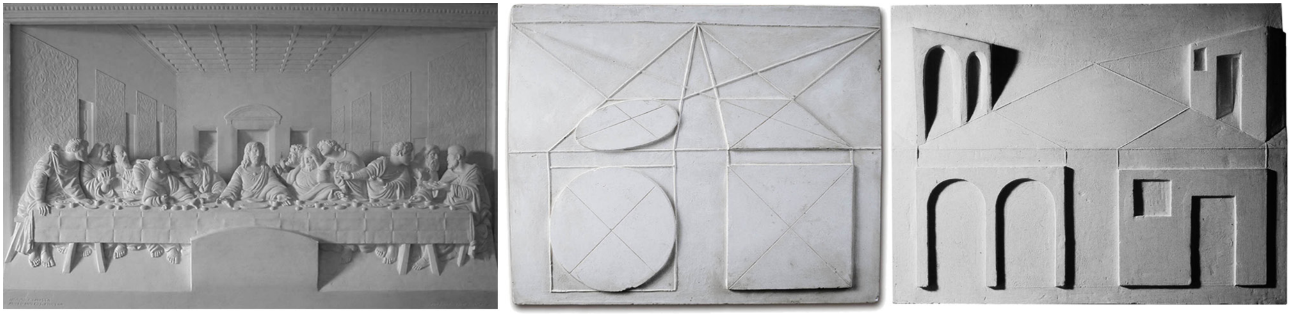
'Unveiling' the perspective-based painted space of *The Feast of Herod* by Benozzo Gozzoli

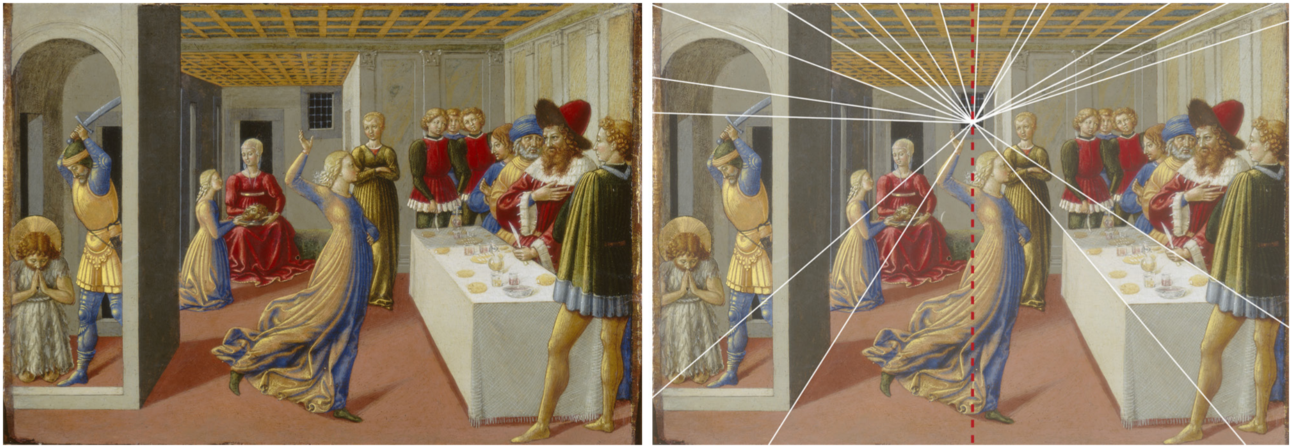
The Feast of Herod by Benozzo Gozzoli (fig. 3) was chosen as case-study because it well suits the research goals. The painting is indeed characterized by a simple and substantially regular one-point perspective with a strong symmetry with respect to the vertical axis, in which the main events of the narration and a number of extra-visual stimuli (e.g. smells, tastes, sounds, music etc.) are all condensed in the spatial-temporal *continuum* of a single static picture. As in many Renaissance narrative paintings, Gozzoli unifies three temporally distinct scenes (fig. 4) in the same perspective-based space. The spatial-temporal reading must be done starting from the foreground and moving towards the background: *Salomé's Dance* is the first event to have happened so it's

Fig. 2. Perspective bas-relief transposition of The Last Supper by Leonardo da Vinci and two preparatory perspective boards of the Anteros Museum in Bologna.

Fig. 3. Benozzo Gozzoli, The Feast of Herod, tempera on panel, ca 1461-1462, 23.8 x 34.5 cm, Samuel H. Kress Collection, National Museum of Art, Washington. Photo credit: National Museum of Art di Washington. On the left, perspective layout with the principal point falling on the vertical axis of symmetry of the painting.

Fig. 4. The three different moments of the narration, highlighted in chronological order.





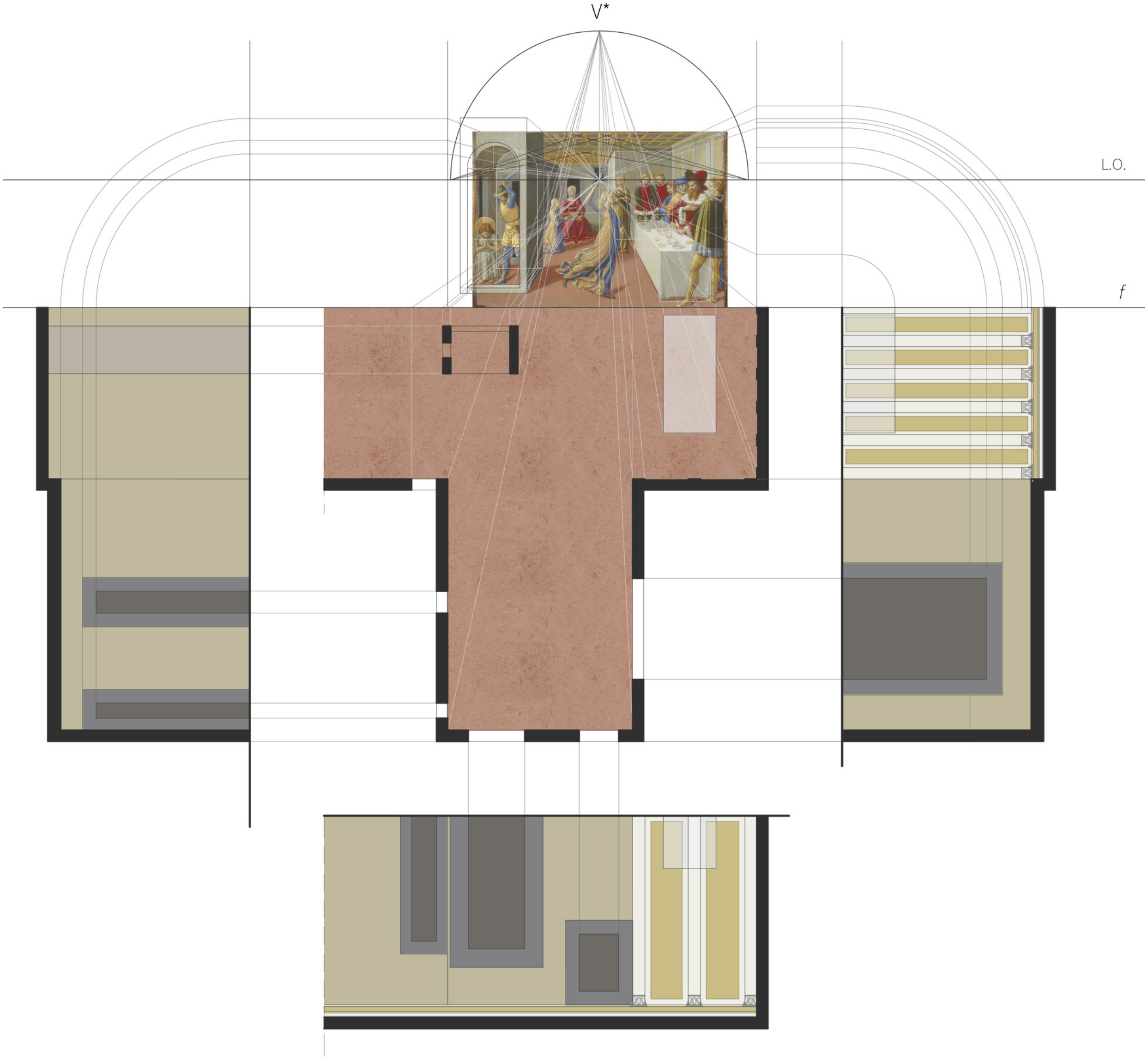


Fig. 5. Perspective restitution of the painted space.

also spatially closer to the viewer; the *Beheading of Saint John* is the second next and it is indeed located on a middle plane; the *Presentation of the Baptist's Head to Herodias* is the last event in the timeline and it is consequently located far away from the viewer, at the very back of the painted space but in a setting that can be considered as an extension of the banquet room. The transition from one scene to another is underlined by architectural elements which, despite the spatial continuity, clearly separate the events; for instance, an *edicola* on the left side of the painting –which recalls of medieval *luoghi deputati* [Pagliano 2005, p. 13]– frames and isolates the execution of Saint John the Baptist, highlighting the most dramatic moment of the macabre episode which deserves intimacy and solemnity. In an artwork like *The Feast of Herod*, perspective represents and measures both space and time: it traces the timeline and arranges all the narrated events, unifying them in a spatial grid in which different temporal dimensions coexist. The research methodology can be divided into the following phases: 1) Geometric restitution of perspective of the painted space; 2) 3D modeling of the restituted space; 3) 3D Modeling of the perspectival bas-relief through accelerated solid perspective; 4) 3D printing of tactile models; 5) Educational model to support the comprehension of perspective; 6) Verbal narration of the painting to support the haptic exploration of the 3D models; 7) Multisensory experience: sounds, smells, tastes, moods.

The perspective restitution of the painted space and the three-dimensional model

The perspective restitution of Gozzoli's painting (fig. 5, 6) has been carried out through the reversed procedure of linear perspective and it revealed the choices made by the artist when planning the space designed to host the events narrated by the Gospels. In spite of the apparent coherence of the perspective layout and beside the minor imperfections due to the brushstrokes and the difficulty of execution on a small format, Gozzoli intentionally made a number of deviations from the rules in favor of the aesthetic value of the final image. Indeed, the final overall effect is always given priority over the formal rigor of painted architecture (*architectura picta*). In the philological restitution, the consistency of the spatial unity was restored by operating a 'correction' of the image to make it perfectly adherent to the perspective's coordinate system and to obtain a regular space, also in view of preparing drawings for the following 3D modeling. Therefore, perspective restitution proved to be other than an automatic translation of a perspective image into plans

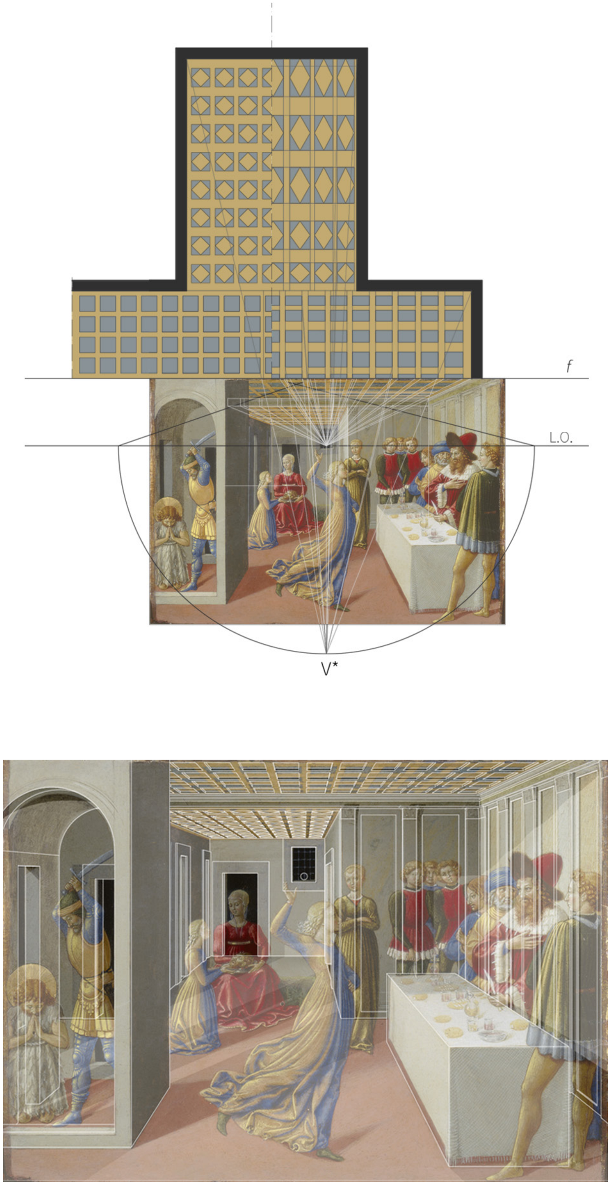
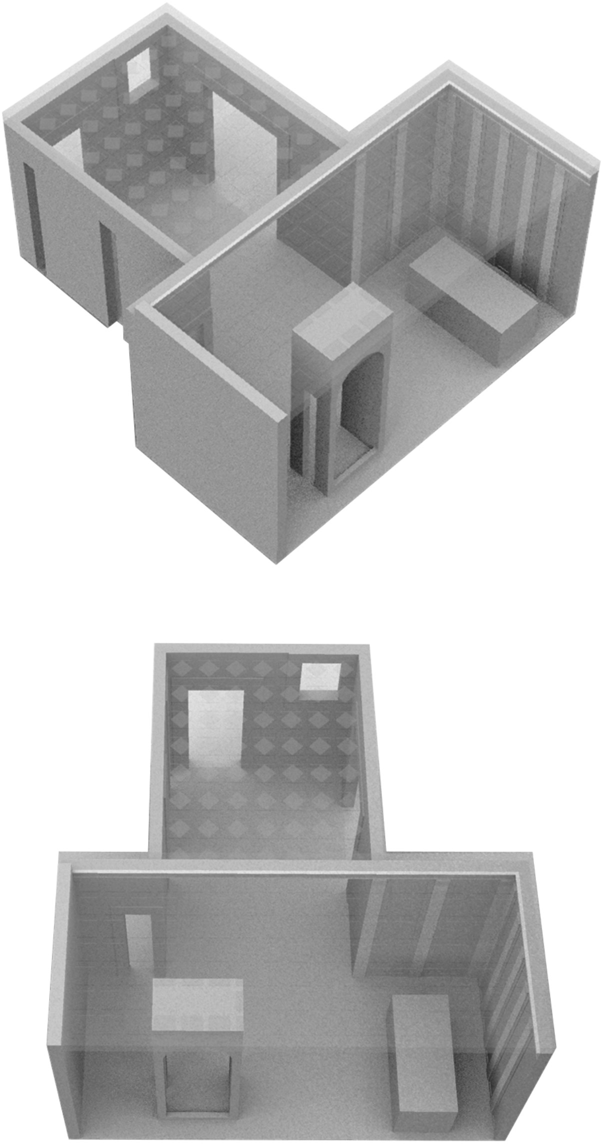


Fig. 6. Perspective restitution of the coffered ceiling compared to the philological restitution. On the bottom, comparison between the original painting and the digital model.

Fig. 7. 3D digital reconstruction of Gozzoli's painted space.



and sections: it is, instead, a true interpretative act capable of revealing incongruences, artistic licenses and deviations from rules. The three-dimensional model digitally constructed starting from the plan and sections obtained through the philological restitution (fig. 7) is quite simple and suitable for a tactile exploration since the painter himself did not overload the image with excessive details and decorations. As a matter of fact, excessive detail would have been an obstacle for the correct tactile comprehension of the spatial system.

The perspective bas-relief

The perspective bas-relief was digitally modeled through the application of accelerated solid perspective (fig. 8) within the depth of the support. It is no coincidence that solid perspective was originally known by the name of 'relief perspective': it was indeed an actual three-dimensional perspective where "a reduced space gave the illusion of a greater depth: such technique was destined to be employed for the creation of sculpted bas-reliefs and theatrical sets" [Sgrosso 2002, p. I]. In this study, the perspective bas-relief was intended as the accelerated solid perspective of a space because such technique allows to erase parallelism, successfully underlying perspective convergence of parallel lines towards the vanishing point, rendering the different depth planes and preserving the centrality of the point of view. Differently from traditional bas-reliefs, the model obtained through accelerated solid perspective is in the round: such choice, besides making the interpretation of the perspective-based space easier for non-sighted people, appears to be more appealing even for a sighted audience. Indeed, it provides a more powerful spatiality and allows the exploration of a space whose 'distortions' and 'foreshortenings' can be perceived through touch. This represents a new way of 'entering' the perspective painting, a new cognitive experience for both sighted and non-sighted people. Such model is thus a more explicative one rather than a *diminutio* compared to the original. Thanks to 3D printing, multiple copies of a perspective bas-relief can be manufactured so that the three different moments of the narration can be isolated and then presented all together in a single synthetic vision (fig. 9). The narrated events are therefore temporally separated, indulging the exploratory modalities of touch and introducing an additional ideal dimension, movement, as if the characters entered the stage in different acts of a theatre performance. 3D printing makes prototyping and experimenting relatively easy and quick as the models can be tested promptly in order to identify issues and improving their features to provide an optimal tactile experience (scale, level of detail, surface textures etc.)

Fig. 8. Application of accelerated solid perspective to the space obtained through the reverse perspective technique.

Fig. 9. Multiple copies of the perspectival bas-relief –each one highlighting a moment of the narration–, the complete bas-relief and a perspective section. Colors can be preserved for sighted users.

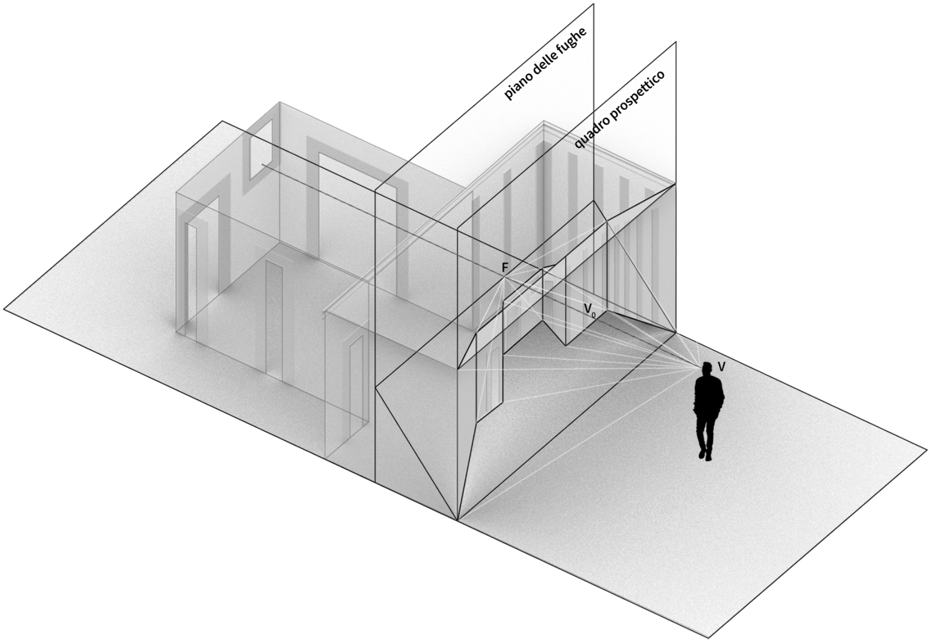
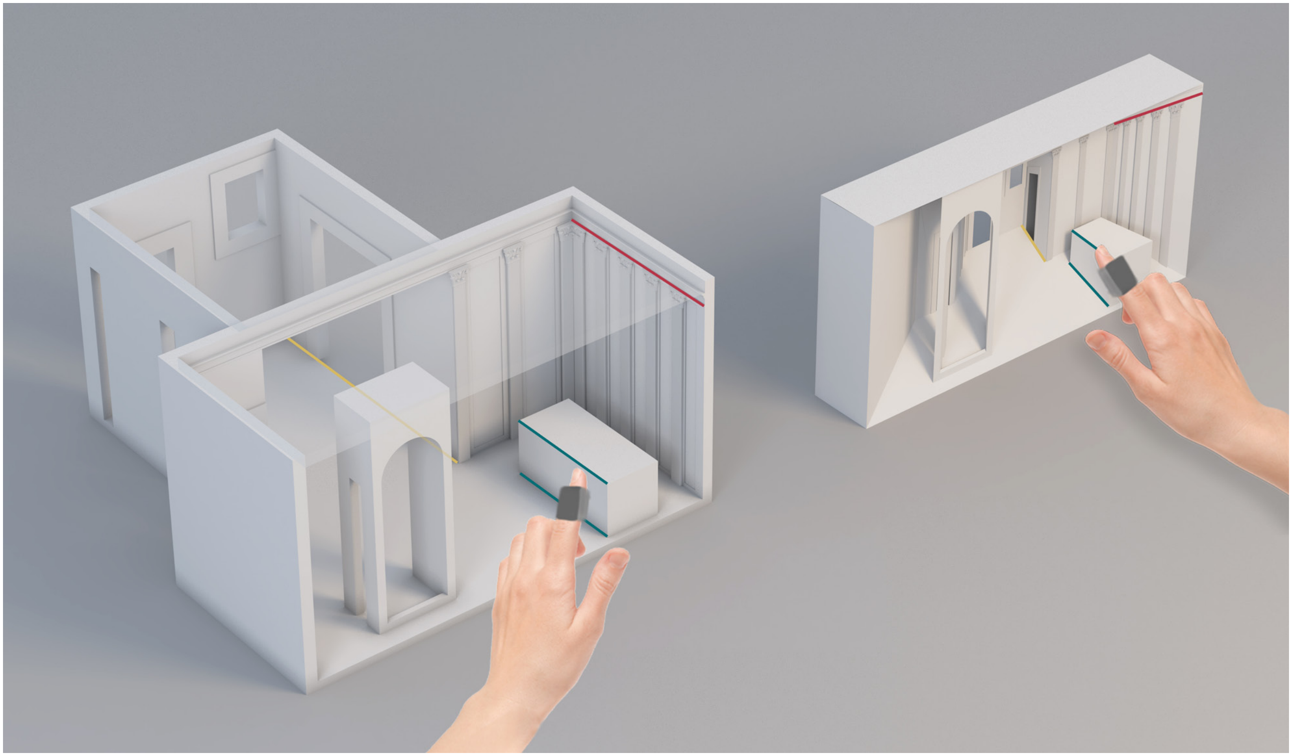
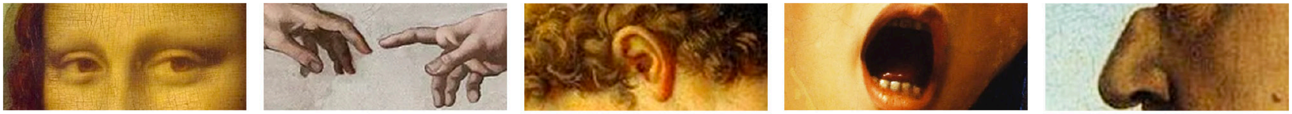


Fig. 10. The comparative educational model.

Fig. 11. Suggestions for a multisensory experience around Gozzoli's painting.





Sight

Augmented Reality

Virtual Reality

Inviting users to see the 3D printed models from the perspective point of view

Touch

Haptic exploration of tactile models

Braille captions

Touching objects or fabric depicted in the painting

Hearing

Verbal description

Sounds evoked by the picture

Music of the Dance of Salomé

Taste / Smell

Smells and tastes of 1st century BC Jersusalem typical food served at the feast.

Body

Inviting users to reproduce the characters' poses and gestures with their own body

The comparison between the returned three-dimensional space and the perspective bas-relief: an educational model to explain perspective

In order to understand the transition from the three-dimensional form of the painted space to its bidimensional perspective image, it was decided to apply the principles behind the aforementioned preparatory perspective boards created by the Anteros Museum in collaboration with the Francesco Cavazza Institute. As Loretta Secchi argues, "this consists of a sort of brand new literacy on the way reality is visually represented" [Secchi 2018, p. 24]. The comparison between corresponding lines on the two plastic transpositions of the painted space (true-form three-dimensional model and perspective bas-relief) enables the visually impaired to recreate a mental model of the painted architectures, justifying the distortions resulting from central projections that 'build' the perspective image and allowing them to identify the actual spatial location of perspective lines. In this way, the visually impaired, whose knowledge of the world mainly rely on tactile perception of forms, can touch and understand the distortions which take place in the process of translation of a space to a plane, discovering that they have a precise and valid significance (fig. 10). It is therefore possible to learn new geometric definitions and experience them first hand through touch. Such path of knowledge must be accurately planned, indulging time and modalities of haptic exploration [4] which is assisted by the remaining senses and supported by an efficient kinesthetic activity. The summation of stimuli provided by volume, texture and hand movement shapes the mental image that, for those who can't see, is the object itself. A 3D model alone is certainly not enough to convey all the values that 'build' the identity of an artwork. Tactile reading needs to be complemented, guided and supported by a verbal description, in order to ensure a correct decoding of forms as long as the iconographic and iconological understanding of a painting. For a blind person relating to a pictorial artwork, the evocative and iconoclastic power of speech is an essential and irreplaceable resource that needs to be carefully calibrated in order to avoid falling into the trap of verbalism. A correct integration of sense and intellect, through which the blind individual can imagine reality and access a real aesthetic experience, can take place thanks to the synergistic relationship between language and tactile reading: speech guides imagination so it can get where hands cannot touch. So, "if *ekphrasis* is defined by Ermogene as a 'descriptive discourse that efficiently makes the object perceptible to the human eye', it is possible to talk about an *ekphrasis* sui generis that must be able to efficiently make the object perceptible not to the human the eye but to the hands" [Sòcrati 2018, p. 34].

The multisensory experience

Nowadays, museums are no longer places were artworks are simply housed and preserved for future generations; the museum experience can become a multi-dimensional journey, involving proprioceptive, sensory, intellectual, aesthetic and social aspects. Touch is the main sensory compensation to sight since it's the only one which is able to explore and recognize form. Nevertheless, touch and sight are not the only resources that our body can count on to establish a relationship with objects and especially with the work of art. Furthermore, modern neurosciences argue that inner representations of reality are intrinsically multisensory. While observing a painting, "it is not true that visual features are central and all other qualities are placed around them as if they were ancillary. Nothing could be further from the truth" [Dewey 1951, p. 150]. In the artistic experience, the different sensory features indeed overlap, intersect and interact; touch, color, smell, light, taste are constantly combined, stratified and connected in the body of who is living the experience.
In the case of the *Feast of Herod*, the subject already provides many inputs and suggestions for an exhibition strategy which enhances the knowledge and accessibility of the artwork by engaging more than one sense. Experiencing the painting becomes a multi-dimensional 'immersive' journey, in which stimuli produced by hearing, touch, smell and taste and their bodily resonance can reveal new meanings and unexpected sensations. The table shown in fig. 11 presents a few suggestions for a multisensory experience based on *The Feast of Herod*.

Conclusions

Blind people can certainly experience an authentic aesthetic experience, even if through a different path outlined by the needs of tactile exploration. However, their relationship with *perspectiva artificialis* is more controversial since perspective itself has its roots in optics and therefore it is deeply connected with the physiology of human sight (*perspectiva naturalis*). Despite being unable to directly experience it as they do not possess an intuitive or innate biological predisposition, blind individuals can understand the functioning of perspective by learning the graphic-geometric process behind perspective-based painted spaces through a special education which does not require the use of sight. Traditional techniques of descriptive geometry (geometric analysis, philological restitution) along with modern digital technologies (3D modeling, 3D printing) and supported by a multisensory program for the artwork storytelling can provide an educational multi-modal model to convey –to everyone– the whole 'world' contained in a bidimensional image. As Howes states, "the experience of a painting need not be mediated by sight alone, as if its visual surface were the only sensory dimension that mattered. The painting itself may represent a transposition of an auditory or tactile experience into a visual one […] and even if it doesn't, there is no intrinsic reason not to enlist other sensory channels in one's perception of it by constructing a multisensory model of its topology in the intervening space between the painting and the perceiver" [Howes 2014, p. 297].

Notes

[1] Cfr. Secchi 2004; Arnheim 1990; Grassini 2016.

[2] Cfr. Nasini 2006.

[3] <http://www.cavazza.it/drupal/it/node/335> (accessed June 9, 2020).

[4] For further reading about touch modalities, see: Hatwell, Streri, Gentaz (eds.) 2003.

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