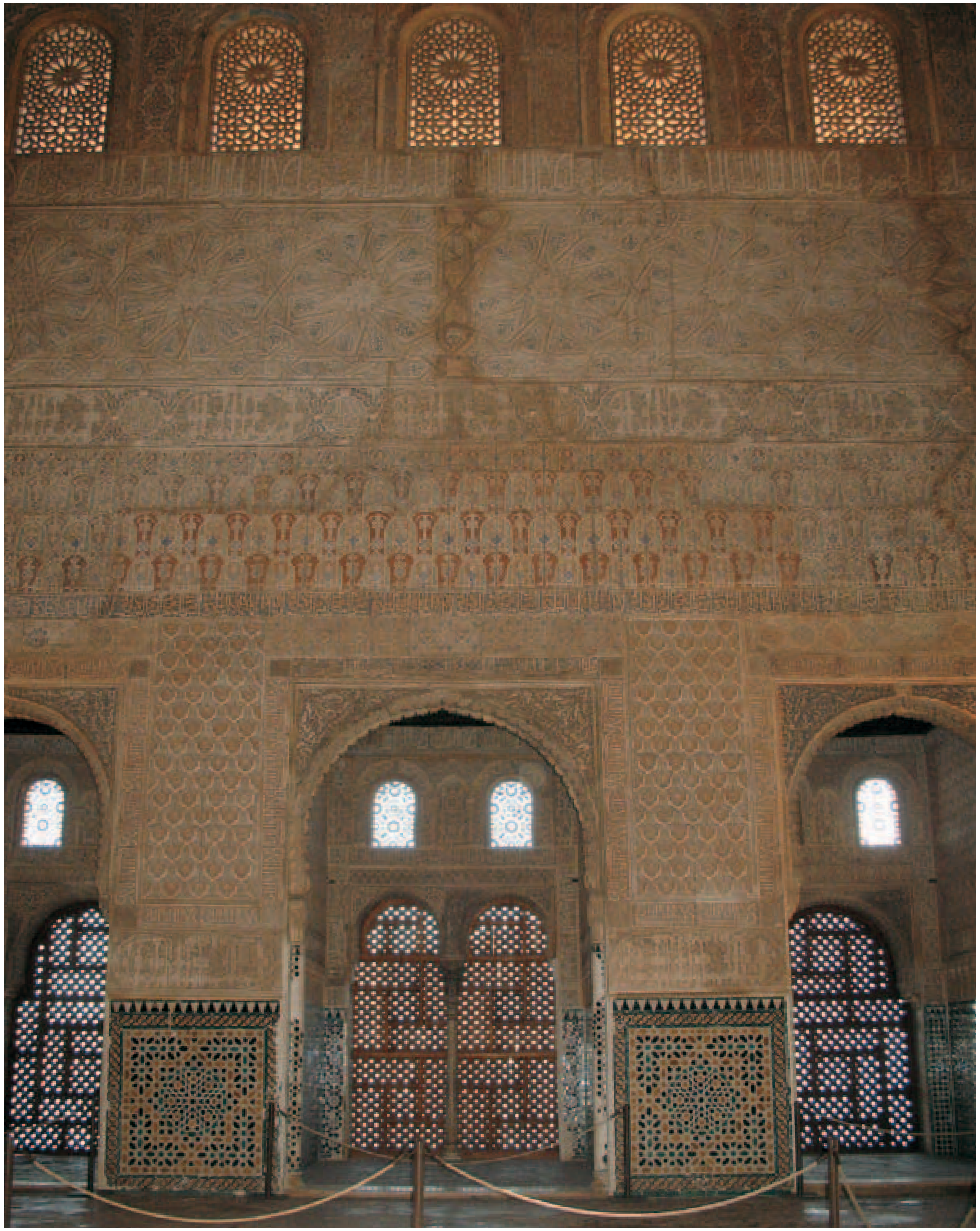
التصاميم إما متعددة الألوان أو مذهبة: جمالية اللون في قصر الحمراء

1

"Designs Always Polychromed or Gilded"

THE AESTHETICS OF COLOR IN THE ALHAMBRA

OLGA BUSH



In an interview with the French painter François Morellet given in connection with the exhibition 'Color Chart: Reinventing Color, 1950 to Today' at the Tate Gallery, Liverpool (Morellet 2009), the artist commented on his work *Random Distribution of 40,000 Squares Using the Odd and Even Numbers of a Telephone Directory* (pl. 39). He explained the process of painting the initial version of *Random Distribution* in 1960: "I drew horizontal and vertical lines to make 40,000 squares. Then my wife and my sons would read out the numbers from the phone book [. . .], and I would mark each square for an even number while leaving the odd ones blank. The crossed squares were blue and the blank ones red." The random sequence challenges the rationality of the underlying grid and hence the canons of Western painting. But in addition to the interplay with geometry, Morellet's painting further attests that the properties of the colors themselves can be manipulated to foment a particular visual experience.

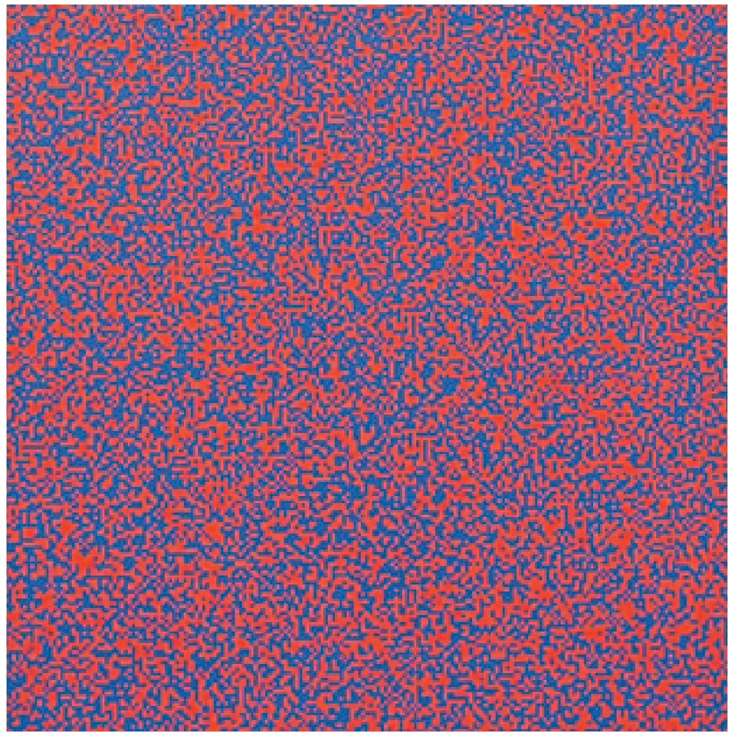
While the theoretical issues of artistic conception and visual perception in the use of color and its relation to geometry will be the primary focus of this essay, Morellet also enumerated the pictorial sources of his *Random Distribution* in more conventional art historical terms. He cited his early enthusiasm for Oceanian Tapas "with their repetition of printed shapes," followed by his encounter with contemporary Concrete art. Finally, he recalled: "My third major shock came from the abstract Islamic networks of lines and repetitive pattern all over the walls of the Alhambra Palace in Granada on my first visit in 1952" (Morellet 2009).

This essay will investigate that shock, turning from the contemporary experience of Morellet to the aesthetic experience of the Alhambra (see pl. 56) as it would have presented itself during the Nasrid period in fourteenth-century al-Andalus. Indeed, that experience will stand forth as all the more shocking by coupling the impact of the "networks of lines and repetitive pattern" cited by Morellet to that of the vibrant colors that overlay the well-studied geometric design. For, as the Nasrid court poet and vizier Ibn al-Jayyab wrote in verses inscribed in the interior of the tower-palace in the Alhambra known as *qalahurra al-jadida*: "Wherever you look, there are different designs / always: either polychromed (*muzakhraf*) or gilded (*mudhahhab*)"[1] (García Gómez 1996, 142).

The argument for the indispensability of color to the understanding of the aesthetics of the Alhambra requires two preliminary steps. First, given the state of conservation in which the interior halls of the palaces (pl. 38) and the spacious arcaded courtyards above the mosaic tile dados now appear mostly devoid of color, it is necessary to provide a historical assessment of the extent, variety, and sources of color in the decoration of the Alhambra.

Second, with respect to visual perception medieval Muslim science will be considered as the theoretical foundation for the use of color and its relation to geo-

38 (*facing page*) Comares Palace, Alhambra, 14th century.



39 François Morellet, *Random Distribution of 40,000 Squares Using the Odd and Even Numbers of a Telephone Directory*; 1960. Collection Musée d'Art et d'Histoire de Cholet.

metric design in that decoration. Here the task is hampered by the lack of historical documentation. Nevertheless, it would be more absurd to imagine that the builders and artisans working under the patronage of the Nasrid dynasty in fourteenth-century Granada produced the magnificent decoration of the Alhambra in a vacuum than to speculate about the salient elements of their cultural context, including the science of their day. Hence, scholarly discussion, culminating in the work of Antonio Fernández-Puertas (1997), does not ascribe the extraordinary coherence of geometrical design in the architecture and decoration of the Alhambra to a random distribution of ratios, even if it has not been possible to connect particular mathematical texts or architectural manuals to specific workshops. With regard to medieval Islamic optics, the picture is clearer, for the chief figure is well known: Ibn al-Haytham (d. *circa* 1040), a mathematician who was born in present-day Iraq and lived much of his life in Fatimid Cairo, was well versed in the arts and sciences of classical antiquity, especially the fields of geometry, optics, philosophy, and aesthetics. The second step, then, will be to consider design principles in the relation of color to geometry in the Alhambra in the light of his optics, drawing further on recent work in neurobiology.

To register the shock of color in the Alhambra, one might well look to the baths of the Comares Palace (pls. 40 and 41), long off-limits to visitors. Rafael Contreras, who succeeded his father José Contreras in 1847 as architect in charge of the Alhambra, undertook the restoration of the original colors on stucco and wood in the baths, producing what one scholar (Díez Jorge 2007, 33) called a "hall of unexpected marvels." Scholarly consensus, however, now rejects the bright and glisten-

40 (*facing page, top*) Undressing room (*bayt al-maslakh*) in the baths of the Comares Palace, Alhambra, 14th century.

41 (*facing page, bottom*) Detail of the stucco decoration of the undressing room (*bayt al-maslakh*) in the baths at the Comares Palace, 14th century.

42 (*left*) Court of the Lions, Alhambra, 14th century.

43 (*right*) Capital in the *mishwar*, Alhambra, 14th century.

ing hues of Contreras's restoration, including his use of ultramarine or Prussian blue and his extensive gilding, as an under-informed and over-zealous treatment in the spirit of Romanticism (Vílchez Vílchez 2001, 47; Puerta Vílchez 2007, 206). Nevertheless, recent study (Marinetto Sánchez 1985; Puerta Vílchez 2007, 215) has also determined that restoration work undertaken earlier by José Contreras eliminated the polychromy on 129 of 130 column capitals in the Court of the Lions (pl. 42), despite the fact that traces of the original pigments were preserved on the marble capitals elsewhere in the Alhambra, for instance in the Hall of the Kings and in the council chamber or *mishwar* (pl. 43). It appears that José Contreras mistook the oxidized gold leaf for a residue of accumulated dirt (Marinetto Sánchez 1985, 84–89). The latter approach resulted in the blanched austerity associated with Western classicism in much of the modern period and still vaunted in tourist materials for Granada. But the repudiated restoration of the bath, if inaccurate, is nevertheless closer to rendering the overall impression of the fourteenth-century Alhambra: a site of intense, even overwhelming color. One may also look to Owen Jones's attempt to reconstruct the colors of the Alhambra in the plates (pl. 44) made from his numerous drawings executed during his visits there in 1834 and 1837 for a striking contrast to the Alhambra of today.[2]

This impression of glittering color can be elaborated and strengthened, for even today traces of pigments are visible on many decorated surfaces throughout the palaces of the Alhambra (pl. 45). Moreover, Ibn al-Jayyab's poetic description of the polychromed interior has been corroborated by recent technical studies of the stucco, in which the pigments and their sources were identified with the aid of Raman microscopy and optical microscopy (Burgio 2004; Borges 2004). The red pigment was obtained from one of two sources: cinnabar, a natural compound mined in Spain, or vermilion, artificially produced mercuric sulfide (Borges 2004,

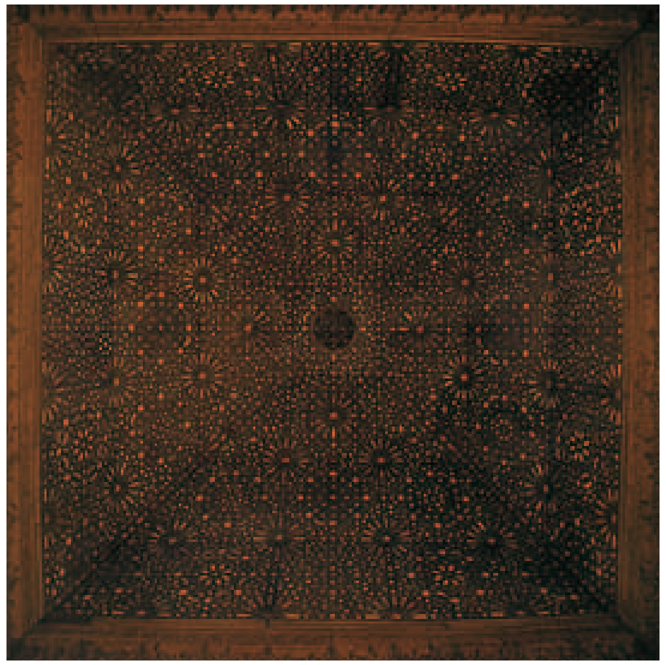
44 Decorative plaster panel on the north, east and west walls between the *qubbas*, Hall of Comares, from Jules Goury and Owen Jones, *Plans, Elevations, and Sections, and Details of the Alhambra* (London, 1892–45), pl. xx.

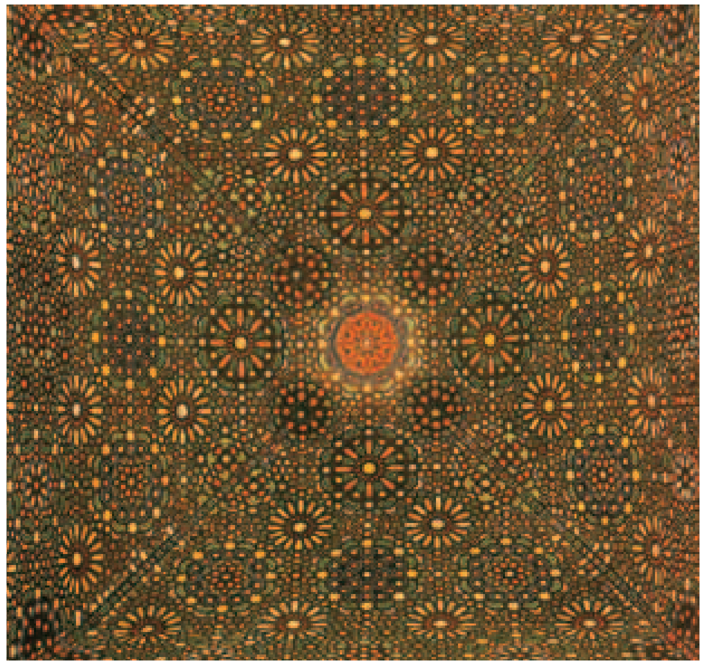
12). The blue pigment came from lazurite, which forms the bulk of the gemstone lapis lazuli, and which, when ground coarsely and mixed with hematite, produces an intense blue hue.[3] Although the green pigment in the Alhambra was not analyzed in these studies, on the basis of the examination of the stucco at an earlier Nasrid palace in Granada it is possible to infer that a mixture of ground malachite and copper was used.[4] Red and blue pigments were consistently employed for the background elements in stucco. Gold leaf was applied to foreground forms, epigraphy among them; and black, turquoise, and green were used for details.[5] A chronicle written in 1362 by Ibn al-Khatib, vizier and poet at the Nasrid court, recorded that the parietal epigraphy in the Alhambra was painted with gold, and lapis lazuli (*lazwurd*) was used to paint the space between the letters (García Gómez 1988, 124).

45 Details of the stucco decoration in the Sala de la Barca, Comares Palace, Alhambra, 14th century.

Further technical analysis has produced similar findings for the wooden surfaces in the Alhambra (pls. 46 and 47). María Carmen López Pertíñez has identified some of the material sources of the colors employed in the background: lapis lazuli for blue pigment; mercury sulfite for vermilion red; a mixture of copper, salt, and vinegar for dark green; and orpiment for yellow. Details on stucco and wood were rendered in greenish blue, black, and white pigments, identified as lazurite, vegetal-based charcoal, and lead carbonate, respectively.[6] In addition, gold leaf was used in the rendering of the foreground decorative elements, such as the foliate motifs on the *artesonado* ceiling of the Comares Hall (Fernández-Puertas 1997, 396).

While stucco and wood are ubiquitous in the palatial complex, the ceiling of the belvedere known as Mirador de Lindaraja (pl. 48) is the only precinct in the Alhambra in which some of the original colored glass remains.[7] The number of colors in the glass ceiling is limited to four – red, blue, yellow, and green – corresponding to the main colors employed in the polychromed stucco and wood. Not only is the color scheme similar, but also the sources of the pigments were probably the same for glass as for the other media.[8] A recently discovered treatise written by the acclaimed chemist Jabir ibn Hayyan (*circa* 721–815), and thought to have been lost, contains many recipes for coloring glass and so indicates that already during the early Abbasid period cinnabar was used for red, arsenic and sulfur for yellow, and copper for green (al-Hassan 2009). Because the lower temperature resistance of lapis lazuli renders it unsuitable for coloring glass, cobalt ore was used to produce a similar blue pigment in this medium, in contrast to stucco and wood (al-Hassan 2009, 137). It may be noted in passing that not only did Jabir ibn Hayyan's treatise become a source for similar later works composed in Arabic and Latin during the next four centuries (al-Hassan 2009, 128–33), but also



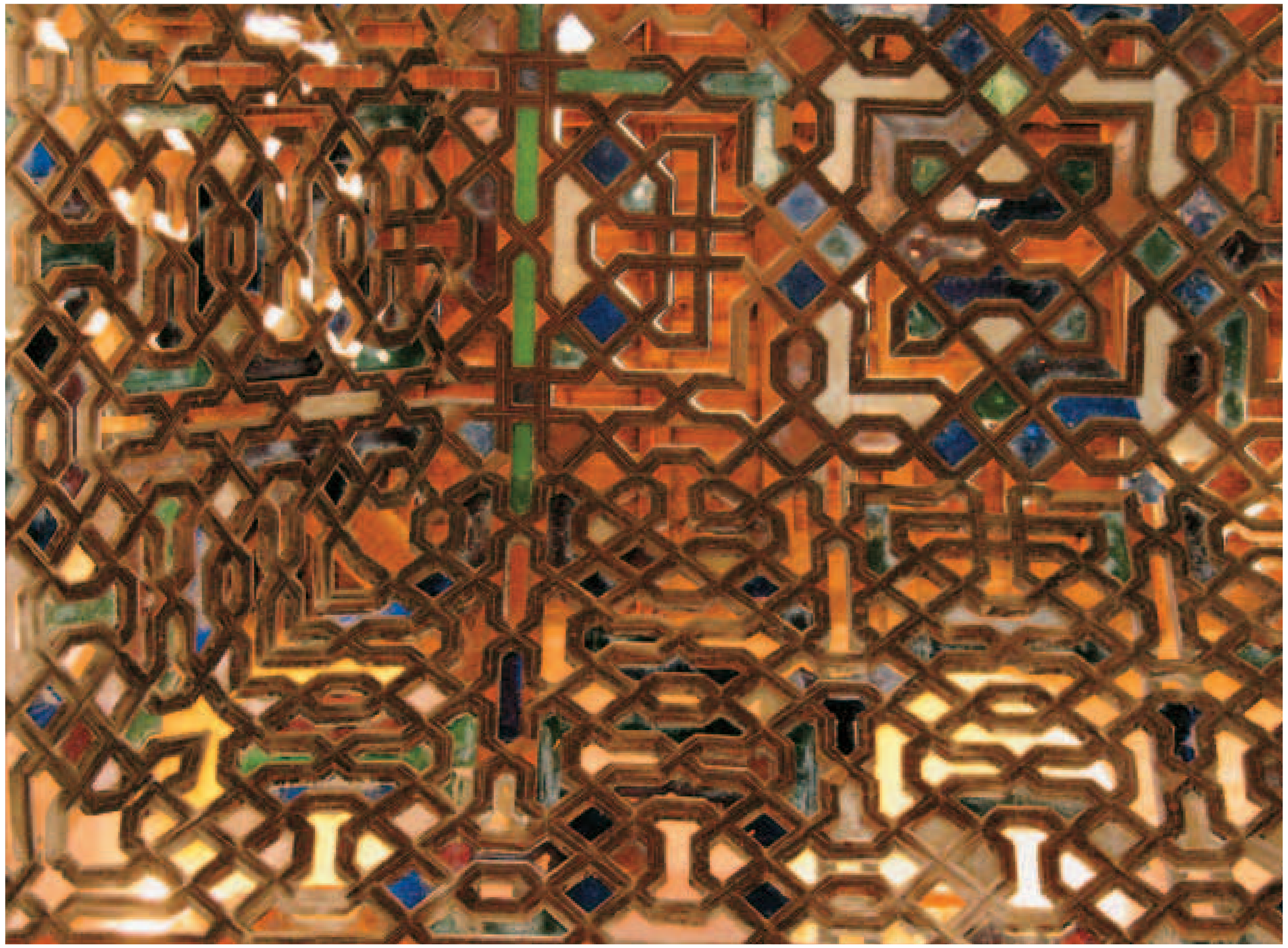


46 (*left*) *Artesonado* ceiling, Hall of Comares, Comares Palace, Alhambra, 14th century.

47 (*right*) Reconstruction of the color scheme of the 14th-century *artesonado* ceiling of the Hall of Comares, Comares Palace, Alhambra, after Darío Cabanelas Rodríguez. Patronato de la Alhambra y Generalife.

his understanding of the relationship between pigments and the temperature of chemical reactions allowed him to propose a method for coloring gemstones that was patented in the United States only in 2006 (al-Hassan 2009, 137). Finally, it seems that the pigments used for coloring glass were also employed in the glazes of tile mosaics, since the polymath al-Biruni (973–1050), among other writers, noted that "Glass, enamel, and ceramics are close to each other and they have common techniques in pigments and methods of coloring" (al-Hassan 2009, 136). Cobalt, for example, was employed in the ceramic production in the Alhambra, for both tiles and lusterware (Álvaro Zamora 2007, 356; Rubio Domene 2006, 266–69).

Technical information on pigments in the Alhambra remains limited, yet even that limited amount suffices to revise the impression left by the loss of color caused by the effects of time or misguided restoration. It is necessary, therefore, to reimagine the Alhambra in an Andalusian tradition that includes the multicolored glass mosaics of the mihrab in the Great Mosque of Córdoba, along with its domes, polychromed wooden ceiling, red and white voussoirs, and marble columns; the polychromed carved stucco and glass in the palace of al-Ma'mun (r. 1043–75) in Toledo and a pavilion of colored glass that he built there as well; and the colored glass in the Aljafería palace of Ibn Hud (r. 1081–85) in Saragossa.[9] One must reconstruct the fourteenth-century beholder's aesthetic experience in the Alhambra amidst great surfaces of rich and varied colors in virtually every facet of the architectural decoration: cupolas, flat ceilings, and doors made of wood; glass vaults and the windows of the upper stories; carved stucco panels covering the expanse of walls and stucco *muqarnas* vaults; marble and stucco capitals; and tile mosaic in the dados and on the floors.



48 Glass ceiling of the Mirador de Lindaraja, Alhambra, 14th century.

The effort of imagination necessary to reconstruct the colors of the architectural decoration is facilitated, of course, by the extant dados of tile mosaic, today the most colorful and best-preserved surfaces in the Alhambra. But even here scholarly attention has focused instead on geometric design. Mathematicians in the field of fractal geometry, for instance, have found that all of the seventeen possible two-dimensional symmetry groups discovered by Plane Crystallographic Group Theory are employed in the tile mosaics of one or another precinct in the Alhambra.[10] But inasmuch as fractal geometry was unknown to the medieval world and the pertinent developments in crystallography awaited the discovery of x-rays, the same scholars have proposed that the builders and artisans of the Alhambra were able "to carry out [the designs] empirically," a conclusion that is akin to suggesting a random distribution of trial and error (Pérez Gómez 1995, 44). In the absence of documented knowledge of mathematical principles, contemporary scholars claim no more than "intuitive knowledge" as a basis for design (López Rodríguez et al. 2003, 37). A study that took color into account broadened the narrow cultural scope framing that mathematical research. That is, when geometric patterns were examined through the lens of symmetry-based coloring schemes, the scholars concluded that the Nasrid artisans had "understood and used" the principles of what crystallographers term dichronic and polychromatic patterns (Makovicky and Fenoll Hach-Ali 1999).

We can advance our understanding of the design principles by reversing the historical perspective. Rather than study the medieval decoration as a distant and incomplete prefiguration to be fulfilled by modern knowledge, one may suppose that the designs manifested the state of knowledge of their own times. The inseparable relation of color and geometry, then, reflects visual perception as it was conceived in the medieval period. That conception was best expressed, at least as far as extant documents are concerned, by Ibn al-Haytham's groundbreaking treatise on visual perception, the *Kitab al-manazir* (Book of Optics).

Although Ibn al-Haytham's other works on optics received attention in the writings of mathematicians and philosophers of the Muslim world in the eleventh and twelfth centuries, it appears that his "Book of Optics" was not widely used at this time. Even so, it has been suggested that some parts of the treatise were known already in the Iberian Peninsula in the late eleventh century, particularly at the court of Ibn Hud, the *taifa* ruler of Saragossa and himself a mathematician of some repute (Sabra 2007, 128). It is likely that Ibn al-Haytham's works on optics were known even earlier at the court of another *taifa* ruler, al-Ma'mun of Toledo. Sa'id al-Andalusi (1029–1070), in his "Book of the Categories of Nations," which was written in 1068 in Toledo and records the names of famous Muslim scientists and their main contributions, mentions Ibn al-Haytham as the author of a treatise on concave mirrors, that is, another work on optics (Andalusi 1991, 55). Moreover, Sa'id al-Andalusi's book gives plentiful evidence of an extensive exchange of scientific knowledge between Andalusia and the Muslim East through the travels and studies of Andalusian scholars. 'Abd al-Rahman ibn Isa, the *qadi* of Toledo, for example, met Ibn al-Haytham in Egypt in 1038 (Andalusi 1991, 55 and 58–78). Thus, it is likely that the *qadi* was not only exposed to the scientist's theories, but also may even have brought back works by Ibn al-Haytham when returning to Toledo.

The "Book of Optics" began to circulate anew in a thirteenth-century translation into Latin, probably undertaken in the Iberian Peninsula and known today under the titles *Perspectiva* and *De aspectibus* (Sabra 1989, II: lxxiv; Sabra 2007, 122). Among the seventeen extant Latin translations, there is a manuscript dated 1269 (Sabra 2007, 122 and n. 12). It is possible, then, to suggest that the *Kitab al-manazir* was translated in Toledo in the scriptorium of the king of Castile and León, Alfonso X (r. 1252–84), where two other works of Ibn al-Haytham – "Configuration of the Universe" and "Cosmography" – were also translated (Samsó 2007, 29–31).

The translation of *Kitab al-manazir* had a profound impact on the writings of Roger Bacon, John Pecham, and Witelo in the 1260s and 1270s, thereby further disseminating Ibn al-Haytham's concepts (Lindberg 1976, 58–86). In fact, Ibn al-Haytham's theory attained such recognition that it had already been incorporated into the curriculum of medieval European universities (Lindberg 1976, 121). During the Renaissance period artists and scientists alike became familiar with its precepts through the fourteenth-century translation of the *Kitab al-manazir* into Italian (Necipoğlu 1995, 166), and in the seventeenth century it laid the foundation for Kepler's modern theory of vision (Lindberg 1976, 178–208).

In the Arabic-speaking world Ibn al-Haytham's treatise also regained prominence at the end of the thirteenth century, when Kamal al-Din al-Farisi (d. 1318) wrote an extensive commentary on it entitled *Tanqih al-manazir* (Revision of the "Optics"; Sabra 1989, II: lxiv–lxxiii). The theoretical concepts presented in the *Kitab al-manazir* were disseminated throughout the Islamic lands through numerous copies of al-Farisi's *Tanqih*. Taken together, the distinctive *maghribi* script used in some of the Arabic manuscripts of the *Kitab al-manazir*[11] and the Iberian provenance of its earliest Latin translation suggest that Ibn al-Haytham's theory of visual perception and its aesthetic corollaries circulated in the western Mediterranean in the realms of the Nasrids and the Marinids. Thus, in a recent discussion of Ibn al-Haytham's contribution to the theory of perception, Hans Belting (2008, 106) stated, with respect to the Muslim elite of al-Andalus, that the *Kitab al-manazir* was "in everyone's hands."

There is as yet no textual evidence to confirm that the architects and craftsmen at the workshops of the Nasrid court had direct knowledge of Ibn al-Haytham's *Kitab al-manazir*, but then those architects and craftsmen themselves have yet to be identified. Indeed, virtually nothing is known of the Nasrid royal workshops and hence of the instruction and professional formation of their members. Nevertheless, the work that these unknown artists left behind clearly attests to systematic design principles, principles that may be articulated coherently by reference to Ibn al-Haytham's optics.

Based on ocular anatomy, intromission theory, mathematics, and the interrelations of various cognitive processes, Ibn al-Haytham's optics explicated the psychological apparatus involved in seeing and comprehending a visual object.[12] In the most basic terms, he outlined a two-step process: the first involves the perception of an object by the optical system; the second involves the comprehension of the object through the agency of the psychological operations of cognition that engage *al-quwwa al-mumayyiza*, "the faculty of judgment" or "of discernment" (Sabra 1989, II: 128–38). Ibn al-Haytham then enumerated the twenty-two visible properties of an object in relation to that two-step process. Light and color are distinguished from all other properties as susceptible of being perceived through "pure sensation." The remaining properties, such as distance, shape, and size, or contrasting pairs, such as similarity–dissimilarity and motion–rest, require the subsequent and supplementary intervention of "judgmental perception," which employs various mental operations, such as contemplation, comparison, deduction, and inference.

On the basis of this two-step process combining physiology and psychology in what he calls "true perception," Ibn al-Haytham offered corollaries with a direct bearing on aesthetics. He postulated that the beauty of an object could be produced in several ways: by a single visible property; by the cumulative effect of several visible properties, each of them beautiful; and finally by a harmonious interrelationship of several visible properties that may lack beauty in themselves. He stated: "Beauty is, therefore, produced by the particular properties, but its completion and perfection is due only to the proportionality and harmony that may obtain between the particular properties" (Sabra 1989, I: 205). His reference to "proportionality of part in regard to shape, size, position" would seem to align beauty with geometric design, and scholarship in Islamic art has indeed tended to assign geometry a leading role. But Ibn al-Haytham immediately added: "and *all the other properties required by proportionality*" (emphasis added), a statement that moves beyond elements conducive to linear measure to include a broader understanding of *wazn* or commensurability. In this regard it is pertinent to recall that the notion of commensurability had been addressed by earlier Muslim texts on aesthetics and that in addition to the proportionality of shapes and sizes, the tenth-century treatise by the Ikhwan al-Safa (Brethren of Purity) specifically mentioned the proportionality of colors needed to render a painted picture beautiful (Sabra 1989, I: 99–100).[13] With regard to the aesthetics of color, Ibn al-Haytham asserted: "bright and pure colours and designs are more beautiful when regularly and uniformly ordered than when they have no regular order" (Sabra 1989, I: 203). This dictum allows a process of discernment within pure sensation – colors may be more or less pure, for instance – and hence the possibility of perceiving beauty in the first step of the act of seeing alone. The single property of color may be beautiful in its purity, and the cumulative effect of the visible properties of color and light, combined as luminosity or value, might also be perceived as beautiful. But the completion and perfection of beauty, with respect to color, will not be achieved through pure sensation in itself, but rather will engage the secondary processes of discernment that are necessary to bring order to color.

It is, then, not the richly colored surface, but the colored surface organized by geometrical design that is the aesthetic foundation of the architectural decoration of the Alhambra. This conclusion upholds the more general observation of Oleg Grabar (1992, 135) that geometry plays a crucial role not only in design, but also in determining the *mode* of perception. But Ibn al-Haytham's two-step optical process leads to a further postulate and with it a shift in emphasis. Since the judgments involved in discerning geometric design are secondary to the perception of

49 Undressing room (*bayt al-maslakh*) in the baths of the Comares Palace, Alhambra, 14th century.

color, according to Ibn al-Haytham, one may also study such visible properties as shape and size, separation and continuity, and motion and rest as dependent upon the use of color.

The Alhambra lends itself to corresponding case studies. Here these are limited to two analyses: one of the tile mosaic dados, surfaces on which the colors are well preserved, the other in which the foregoing historical reconstruction permits a new understanding of an architectural space.

While concentrating on geometrical variations in the tile mosaic dados in the Alhambra, Fernández-Puertas (1997, 356; see also Castera 2008) remarked that the geometric designs were transformed through the use of color, which generated "entirely new schemes to the eye, which often, and to a large extent, hide the basic geometric schemes." This crucial point is clearly borne out in the decoration. One may consider, for example, the designs that include a geometric element, which, for the modern eye, might be termed "propellers." A panel of dados in the undressing room or apodyterium (*bayt al-maslakh*) in the baths of the Comares Palace (pl. 49) is composed of horizontal rows of alternating black and green propellers,

50 Ceramic tile mosaic on the dado of the west wall of the northwest niche in the Comares Patio, Comares Palace, Alhambra, 14th century.

anchored by a row of yellow ocher ones that serves as an axis of symmetry in the composition. Every second row in the panel consists of white "propellers" perceived merely as a background for the other contrasting colors. While it is possible to discern a pattern of alternating white diagonals, the employment of darker colors, especially black, guides our "reading" as a pattern of horizontal rows. When this panel is compared with the tile mosaic dados in the niche in the northwest corner of the Comares Patio (pl. 50), one perceives a distinct design despite the identical geometric composition. Here the rows of white propellers may be perceived horizontally, but the four colors – black, green, blue, and yellow ocher – predominate over the white grid so that the panel appears rather as a more complex diagonal composition. Since the beholder perceives the pure sensation of color differing from row to row before the similarity in the geometric element of the "propellers," the observer's eye races along the rows of color, recognizing a repeated pattern.

José Miguel Puerta Vílchez (2007, 216) suggested that the design of this panel evokes water. It may be added that the beholders would also have had before them the effect of ripples stirred on the water by the wind on the surface of the reflect-

51 François Morellet, *Violet, Blue, Green, Yellow, Orange, Red*; 1953. Centre Georges Pompidou, Paris.

ing pool in the same Comares Patio. Describing the tile mosaics elsewhere in the Alhambra in 1362, the poet Ibn al-Khatib (García Gómez 1988, 124 and 143) speaks of an "undulating sea" (*maja bahr al-zillij*). While one might suggest that the architectural decoration thus "captures" permanently an ephemeral perception, it may be argued instead that the use of color deliberately destabilizes a static geometric design, introducing a certain dynamism into the architecture.

This design in particular seems to have made an impact on Morellet as well, when he composed his pattern of colored crosses staggered diagonally on the canvas (pl. 51). Executed in 1953, one year after his sojourn in the Alhambra, the painter called the beholder's attention to colors in the title of the painting, *Violet, Blue, Green, Yellow, Orange, Red*. The undulating effect of the dados is lost, however, through the elimination of the white grid and the use of more stable, monochromatic elements.

When color was manipulated further in the tile mosaics in the Comares Patio, yet another, perceptibly distinct design emerged. The dados of the two lateral niches are identical except for one panel on the north wall in the niche in the northwest corner (pls. 52 and 53). In this panel, some of the "propeller" elements are black, whereas they are various colors in the corresponding places in the design discussed above. As Ibn al-Haytham observed, one differentiates between an object's color and that of its surroundings (Sabra 1989, 1: 171–73); in other words, distinctions in color serve to mark "the boundaries of the objects and of the intervals between the boundaries" (Sabra 1989, 1: 187). The use of black in this panel, whether understood as a distinct color or an interval between bounded colors, transforms the undulating rows into a lattice grid. In one horizontal row a cell filled with blue elements alternates with one filled with yellow ones, and in the second row all

52 (*left*) Ceramic tile mosaic on the dado of the north wall of the northwest niche in the Comares Patio, Comares Palace, Alhambra, 14th century.

53 (*right*) Detail of pl. 52.

cells are filled with green elements. While the question as to why the panel was executed with a distinct design must be reserved for a separate occasion, these examples clearly show that differences in color, especially the use of black and white, lead to different "readings" of otherwise similar or even identical geometric designs.

The paucity of traces of pigments in other media in the Alhambra presents an obstacle to current research. Nevertheless, the recollection that the decoration was always polychromed and gilded makes it possible to consider the effect of color on such surfaces as the *muqarnas* vault in the Hall of the Abencerrajes (pl. 54). Ibn al-Haytham explained that the volume, or solidity as he called it, of an object is perceived because the light it reflects renders the surfaces as bent – convex or concave – so that some parts appear lighter to the eye and others darker or shadowed (Sabra 1989, 1: 168–70). The penetration of light through the paired windows at the dome's star-shaped base and its movement along the vault over the course of the day would in itself create the effect of alternating lighter and darker areas, enabling the discernment of the *muqarnas* tiers. But the perception of the complex, highly textured surface of the vault would have been greatly enhanced by the application of red, blue, and gold pigments, whose traces are visible today.[14] The alternation of colors in the vault also contributes to what Ibn al-Haytham discussed as the separation and contiguity of the constitutive parts of the object, or in this case of individual

54 Vault of the Hall of the Abencerrajes, Palace of the Lions, Alhambra, 14th century.

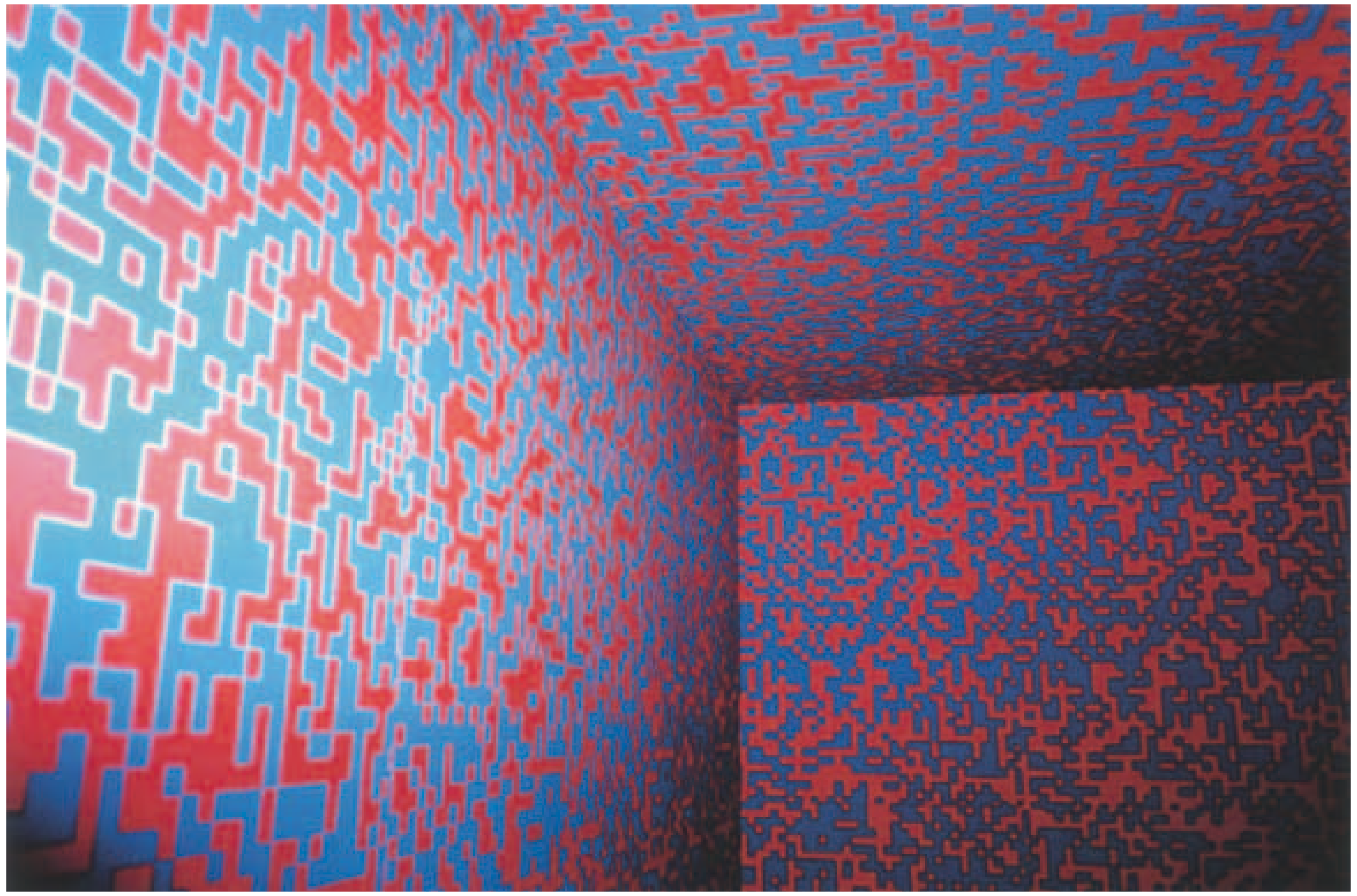
muqarnas elements, setting the numerous and varied volumes in relief. Following Ibn al-Haytham's postulations, it becomes evident that the color contrast would contribute to the perception of the multiple relationships between numerous *muqarnas* elements with regard to their size, position, shape, and distance. Thus the simultaneous manipulation of color and geometry through these relationships would lead the viewer to the discernment of the complex spatial construction of the vault, in which the *muqarnas* tiers spiral in a cone-shaped vortex to its apex, producing a dizzying kinetic effect. The experience of the beholder at the time when the colors were intact would have been akin to that attested by Ibn Zamrak's verses inscribed in the Hall of the Two Sisters, in which he describes the *muqarnas* vault there as "*revolving* heavenly spheres," "radiant with enchantments vivid and *hidden*" (García Gómez 1996, 115–16 and 118, emphasis added).

Ibn al-Haytham's two-step process of the perception of light and color, followed by the discernment of other visual properties, can be supplemented by recourse to current work in neurobiology. Margaret Livingstone (2002, 46–47) offered closely related findings when she demonstrated how the different aspects of visual information are processed through two distinct neurological systems. One system, which she called the "What" system, is responsible for the perception of color and recognition of objects; while the other, the "Where" system, is responsible for the perception of space, motion, position, depth, figure/ground segregation, and the overall composition or organization of the visual field, the very same visible properties of objects evaluated and discussed by Ibn al-Haytham.

Livingstone's explication enables a further comment on the contribution of color to the kinetic effects in the vault in the Hall of the Abencerrajes. The masking of geometry might now best be understood as a disruption of the "Where" system. A historical source offers a point of departure. In describing his visit to the palace in Toledo constructed by the *taifa* ruler al-Ma'mun sometime in the mid-eleventh century, Ibn al-Khabir reported that if one looked at the figures in the architectural decoration "fixedly," the beholder was rewarded with the sensation that the forms "moved or made signs to him" (Robinson 2002, 54). The recent excavations on the site of the palace uncovered fragments of stucco decoration carved with figural motifs and painted with lapis lazuli and gold (Dodds, Menocal, and Krasner Balbale 2008, 56). One may imagine alternating colors and an impression of undulation in the decoration at al-Ma'mun's palace parallel to that described by Ibn al-Khatib in the Alhambra.

Morellet's *Random Distribution* opens a new avenue for research in this respect. In 1963 the painter recreated the original two-dimensional work as a three-dimensional installation (pl. 55), stating: "I wanted to create a dazzling fight between two colors that share the same luminosity. [. . .] I wanted the visitors to have a disturbing experience when they walked into this room – to almost hurt their eyes with the pulsating, flickering balance of two colors" (Morellet 2009). The added architectural dimension of the installation gives some sense of the experience that the fourteenth-century beholder would have had in the polychromed and gilded spaces of the Alhambra.

Livingstone (2002, 36–67) provided a theoretical explication for this kind of perceptual experience. Although the color itself is perceived by the "What" system, the "Where" system, which is insensitive to color, perceives a color's luminosity or value. When the "Where" system compares different colors on the basis of their luminosity, it can reach a conclusion with regard to one's perception of depth, three-dimensionality, composition, and motion. The contemplation of Morellet's *Random Distribution* and of the *muqarnas* vault in the Hall of the Abencerrajes causes the "Where" system to perceive the surfaces as vibrating and unstable not because of the difference in hue[15] – red and blue – but rather because the colors are equal in "brightness," that is, luminosity, and the "Where" system cannot assign relative positions in depth to equi-luminant colors.



55 François Morellet, *Random Distribution of 40,000 Squares Using the Odd and Even Numbers of a Telephone Directory*; Paris, Biennale, 1963.

Since the equi-luminant colors cause difficulties in the perception of the spatial organization of the surface – in other words, in distinguishing between figure and ground – the central vision cannot find the focal point of the composition. One's sight is affected by "a kaleidoscopic multiplying of the focal point, or indeed the focal point's dizzying, vertiginous force."[16] When the focus cannot be located, peripheral vision becomes engaged, and the two working in tandem allow one's optical system to perceive such a surface. Geometry serves to counterbalance and stabilize the vertiginous force of equi-luminant colors. In both *Random Distribution* and the vault of the Hall of the Abencerrajes, an elemental form, multiplied in an orderly composition, gives the central vision a point upon which to focus, again and again, and so to achieve a sense of orientation. But Morellet's deliberate effort to exploit this shortcoming of the "Where" system in order to create "the pulsating, flickering balance" of two colors, and with it to produce an experience of visual shock, reveals an important aspect of architectural decoration in the Alhambra. The vertiginous effects of undulating colors would have contested the central vision and the central role of geometry throughout the palace.

Morellet's work leads to one final observation relevant to Nasrid craftsmanship. The inclusion of an electric bulb in the installation version of *Random Distribution* gives a clear indication of his engagement with the science of optics. More than merely a passing reference to contemporary technologies, the bulb points to the painter's awareness that artificial light enhances the red squares, whereas natural light enhances the blue. Recent technical analysis of surfaces in the Alhambra leads to a similar conclusion. Stucco, a primary decorative material there, was made from gypsum, to which powdered marble or eggshell was added to make it harder (Kalaitzidou and Anahnah 2006, 65). The additives would give greater reflectivity to the material and hence provide a base that would give greater luminosity to the colors applied to the stucco. Technical analysis has also revealed that blue and red pigments in the parietal painting in the Alhambra were applied to a special undercoat that would have affected their luminosity (Medina Flórez and García Bueno 2001, 13). Furthermore, the analysis of Nasrid carpentry shows that in order to give greater luminosity to the finished polychromed surface, it was covered first with a layer of unpolished plaster and then with a layer of burnished tin (Fernández-Puertas 1997, 406), followed by a thin layer of lead white and calcium carbonate applied under the blue and red pigments (López Pertíñez 2006, 85). Although documentary proof is lacking, these findings provide evidence at the level of craft that speaks to the awareness of the science of optics in the period and more particularly to the importance of luminosity to the aesthetics of color. The consequences for visual perception were incorporated into the decoration of the Alhambra.

When the investigation of color in the Alhambra attains the same importance accorded to the study of geometry, and when technical analysis provides further information on the luminosity of the pigments that remain on such surfaces as the vault of the Hall of the Abencerrajes, it may be possible to assess whether the signs made to the beholder by the polychromed and gilded decoration were vibrating on the basis of equal luminosity, and then to surmise more about the artistic intent and the level of scientific knowledge that went into the design. Once the colors of the Alhambra are reconstructed, and the optics of the design and its *kinetic* effects are understood, it will be necessary to reconsider any presuppositions about architecture as an embodiment of stability in the Nasrid palatial complex. Instead, its experience may well have been one of constant, kaleidoscopic, multicolored motion.

Notes

1 *mahma lahazta raayta nuqushan wushshiyat/anwauhu fa-mudhahhabun wa-muzakhrafu.*

2 For a discussion of color in Owen Jones's publication (Jones and Goury 1842–45), see Fernández-Puertas 1997, 314, who also suggested (p. 282), that Jones's plates were a source for Rafael Contreras's restoration of the baths.

3 See Borges 2004, 12. With respect to the wall paintings in the Alhambra and other Nasrid buildings, in some cases the blue and red were obtained from lapis lazuli and cinnabar or mercury sulfide respectively, while in other cases grains of hematite (or oxidized iron) served as a source of red pigment (Medina Flórez and García Bueno 2001). For a discussion of the preparation of the surface for wall paintings in Nasrid architecture, see Capitán-Vallvey, Manzano and Medina Flórez 1992. For the use of lapis lazuli within the broader context of medieval art, and more specifically in the twelfth-century wooden sculpture and stone sculpture of the early Gothic cathedrals, see Kargère 2003.

4 Since the sources of red and blue pigments in the plasterwork at the Cuarto Real de Santo Domingo (*qubba dar al-manjara al-kubra*) in Granada are identical to those in the Alhambra (García Bueno and Medina Flórez 2004), it is likely that the mixture of malachite and copper used here was also the source of green pigment in the Alhambra.

5 These very colors in the foreground and background elements are employed even now in the carved stucco decoration that adorns royal palaces, wealthy residencies, and madrasas in Morocco (see Paccard 1980, I: 60–219).

6 Technical analysis of pigments undertaken by López Pertíñez and García Bueno (López Pertíñez 2006, 68–87) confirmed some of the earlier data on the colors and pigments employed in Nasrid carpentry. Cabanelas Rodríguez (1988, 9–13, 59–80, pl. xxv) reconstructed the original polychromy of the wooden cupola of the Comares Hall, based on the original inscriptions that were found on the ceiling. The author refers to various uncertainties in the reading of these terms, a problem that cannot be resolved here. The inscriptions include the terms used for each color, as well as the number of elements to be executed in each of the indicated colors in the assemblage of the *artesonado* ceiling. The color scheme consisted of three different red pigments, two green pigments (light and dark), white pigment, and what appears to be an off-white or a yellowish-white pigment.

7 Scholars agree that some glass fragments are original, as is the wooden framework in which they are set, while other fragments were replaced after a gunpowder explosion in 1590 (Díez Jorge 2006, 178; Jiménez Castillo 2006). For a catalog of the original glass fragments from the buildings in the Alhambra, dated to the fourteenth or fifteenth century and now housed in the Museo de la Alhambra, see Marinetto Sánchez and Cambil Campaña 2006, cat. nos. 106–18. For evidence that lead was also used as a framework for colored glass in the Alhambra at the beginning of the fourteenth century, see Jiménez Castillo 2006, 67.

8 Chemical analysis of medieval glass from various architectural sites suggests that the pigments from the same sources were employed in European cathedrals as in glass vessels made in the lands of Islam (Brill 1999).

9 Red, blue, and aquamarine glass was employed in the architectural decoration of al-Ma'mun's palace in Toledo (Dodds, Menocal, and Krasner Balbale 2008, 55–56).

10 Among the studies of symmetry groups employed in architectural decorations in the Alhambra, the most pertinent are Fenoll Hach-Alí and López Galindo 2003; Pérez Gómez 1995; Ruiz Garrido and Pérez Gómez 1995; Montesinos Amilibia 1995; López Rodríguez et al. 2003; Pérez Gómez, Gutiérrez Calderón, and Ruiz Garrido 2007.

11 The five extant medieval Arabic manuscripts of the *Kitab al-manazir* are all preserved in libraries in Istanbul (Sabra 1989, II: lxxxi).

12 For an excellent synopsis of Ibn al-Haytham's theory of optics, see Sabra 2003.

13 In contrast to the Ikhwan al-Safa's understanding of light and darkness and of black and white colors in spiritual terms, Ibn al-Haytham examined the phenomenon on a scientific basis, both theoretical and experimental. For a further discussion, see Sabra 1989, II: 85–86, and Sabra 2003, 106.

14 Puerta Vílchez (2007, 224) asserts that the traces of polychromy in the vaults of the Hall of Two Sisters and of the Hall of the Abencerrajes are original.

p. 76 Banner of las Navas de Tolosa, Morocco or Spain, early 13th century. Monasterio de las Huelgas, Museo de Telas Medievales, Burgos.

15 In her analysis of the decoration in the Alhambra, Valérie Gonzalez (2001, 85) attributed the "animation of the pictorial plane and a vibration of the surface" to geometric design as well as the juxtaposition of primary colors. González's term, "kinetic geometry," is very suggestive for the issues discussed here, but I would reiterate that the visual effect is due to the equi-luminance of colors, not to their juxtaposition or their designation as "primary" colors.

16 Bice Curiger (2006, 12) considered this effect as one of the main features of the works of Op art, which she re-examined in her exhibition *The Expanded Eye*.