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**Research on Color in Architecture  
and Environmental Design:  
Brief History, Current Developments,  
and Possible Future**

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# Research on Color in Architecture and Environmental Design: Brief History, Current Developments, and Possible Future

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*Abstract:* This article examines some of the outstanding contributions or points of interest in the research and application of color in architecture, from ancient times to the present. The discourses about color are classified by periods and according to the utterers: theoreticians or writers of architectural treatises, archeologists and historians of architecture, architects who have been relevant in professional practice, color theorists coming from the fields of architecture and design, and color researchers related to the International Color Association. As a conclusion, the main characteristics of these discourses about color are summarized, and a point is made about the use of instruments derived from color science in color design, implying that the evolution in the use of color in environmental design and the research in this field will increasingly rely on the interaction between scientists and designers. © 2006 Wiley Periodicals, Inc. *Col Res Appl*, 31, 350–363, 2006; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/col.20224

*Key words:* architecture; environmental color design; history; International Color Association

## INTRODUCTION

The sources of the contributions to the research and application of color in architecture and design that are reviewed in this article can be classified into four types, depending on

their producers, and are related to specific periods on which particular focus will be made.

(1) *Theoreticians or writers of architectural treatises.* The practice of writing treatises that cover all aspects of architecture began in the 1st century with Vitruvius, flourished during the Renaissance, and continued until the 19th century.

(2) *Archeologists and historians of architecture.* The archeological and historical research on architecture shows a peak during the 19th century and still continues.

(3) *Architects who have been relevant in the professional practice.* I will concentrate on the main architects of the modern movement, during the 20th century.

(4) *Color theorists coming from the fields of architecture and design.* I will consider the architects who developed color order systems and the color researchers who have been related to the International Color Association, founded in 1967, mainly through its Study Group on Environmental Color Design, which started in 1982.

## THE FIRST ARCHITECTS WHO CONVEYED KNOWLEDGE ABOUT COLOR

In written sources, one of the first references to color in architecture is found in the treatise by Vitruvius, the Roman architect who lived in the 1st century (Fig. 1). In Book 7, Chapter 7, he deals with natural colors and focuses on the description of pigments and colorants, as well as where they can be found. Vitruvius does not establish a distinction between color and coloring substance, confusing both concepts: “As for colors, some are natural products found in fixed places and dug up there, while others are artificial compounds of different substances treated and mixed in proper proportions so as to be equally serviceable.” In Chapters 10 to 14 of Book 7 he tackles artificial colors

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FIG. 1. Vitruvius (1st century) and one of the first printed editions of *De Architectura Libri Decem* of 1524.



FIG. 2. Leon Battista Alberti (1404–1472) and *De Re Aedificatoria*.

(again, understood as coloring matters), describing the way to produce them. The last two chapters are dedicated to the purple dye obtained from a marine shellfish and to its possible substitutes. Additionally, an interesting aspect is included in Chapter 3 of Book 7, about vaulting and stucco work, where he describes the appearances obtained with polishing instruments: “Just as a silver mirror that is formed of a thin plate reflects indistinctly and with a feeble light, while one that is substantially made can take on a very high polish, and reflects a brilliant and distinct image when one looks therein, so it is with stucco [ . . . ] it is not only brilliant after being subjected to repeated polishing, but also reflects from its surface a clear image of the beholder.”<sup>1</sup>

In his *Ten Books of Architecture*, published in 1452, Leon Battista Alberti (1404–1472) follows Vitruvius’ conception of color, merely as coloring substances or paints “with which the wall may be adorned” (Book 6, Chapter 9): “Of painted surfaces some are done while the work is fresh, and others when it is dry. All natural colors which proceed from the earth, from mines or the like, are proper for paintings in fresco; but all artificial colors, and especially those which are altered by means of fire, require a very dry surface.” In Chapter 10 of Book 7, Alberti makes an observation that relates color to aesthetic values or preferences. When dealing with the decoration of temples, he says: “I am very ready to believe, that purity and simplicity of color, as of life, must be most pleasing to the Divine Being.” However, when referring strictly to the aesthetic values of architecture, he takes a rather narrow point of view, including only geometrical aspects—figures and forms, number, position or location, congruence of parts, proportion, geometrical composition—without broaching color or other aspects of appearance (Book 9, Chapters 5–7).<sup>2</sup> The treatment of color in Alberti’s book *On Painting* (1435) is quite different. Here, the approach is far more abstract and philosophical, relating color to light and making a classification of colors. He even refers to the affective or emotional value of colors.<sup>3</sup> What may be remarked as odd is the fact that he does not follow this wider conception in his book on architecture, completed 17 years later (Fig. 2).

I will not include Leonardo da Vinci’s conception of color in this article, as his work deals specifically with color in painting. Giovanni Lomazzo (1538–1600), instead, published a treatise concerned not only with painting but also with architecture and sculpture.<sup>4</sup> The *Treatise on the Art of Painting, Sculpture and Architecture* was written in Italian and is divided into seven books, one of which is devoted to color and contains a section on the symbolism of the principal colors (Fig. 3).

André Félibien (1619–1695) was a French architect and art historian, secretary of the Royal Academy of Architecture, who became involved in the famous and long discussion between drawing and color held at the Royal Academy of Painting and Sculpture in France. Although he was mainly a defender of the “drawing” side of the debate, he made some relevant contributions to the color theory of his time. For instance, in his book on the *Principles of Architecture, Sculpture, Painting and Other Arts*, published in 1676, appears one of the first descriptions of color mixtures starting from three colors—red, yellow, and blue—termed basic colors. However, this matter is dealt with specifically



FIG. 3. Giovanni Paolo Lomazzo (1538–1600) and an early edition of his *Trattato*, printed in Milan in 1585.



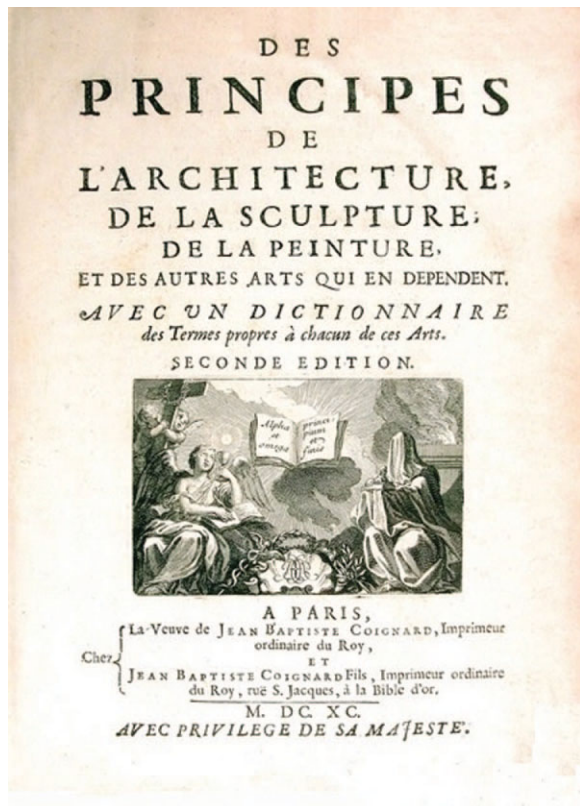


FIG. 4. Front page of the second edition of André Félibien's *Principes de l'Architecture*. . ., printed in Paris in 1690.

in the third book, of painting. In Book 1, of architecture, Félibien writes extensively on color in the section on stained glass and in the section on the technique of gilding (Fig. 4).<sup>5</sup>

#### RESEARCH ON THE HISTORY OF COLOR IN ARCHITECTURE

Let us now take a huge leap in history and land on the middle of the 19th century, when Jacques-Ignace Hittorff

(1792–1867) succeeded in conveying the attention toward a relevant discovery, made previously to him but neglected for many years: the Greek architecture was not white—as it was believed for centuries based on the color of the ruins—but polychromatic. The Greeks used to paint their temples as well as their family dwellings with vivid colors. Hittorff published these findings in his book of 1851 on the polychromy of Greek architecture, where he made a case of the temple of Empedocles in Selinus, Sicily (Fig. 5).<sup>6</sup> The more general acceptance of this evidence came to change a long-held view about the Greek sense of beauty and harmony. However, it took some time to change the traditional notion, and the neoclassicist architects of the 19th century continued to make neoclassic buildings (based on the orders of Greek architecture) in gray, white, or with a monochromatic appearance. As a practicing architect, Hittorff was an exception, since he made polychromatic buildings, as it can be seen in his Winter Circus, in Paris, and in some of his other buildings.

Owen Jones (1809–1874) and Gottfried Semper (1803–1879) were two 19th century architects who also deserve a special mention due to their contributions to the study of polychromatic architecture. Jones was the “colorist” of the Crystal Palace, built by Joseph Paxton in 1851,<sup>7</sup> and wrote *An Attempt to Define the Principles Which Should Regulate the Employment of Color in the Decorative Arts* (1852), *Color in Architecture and Decoration: An Apology for the Colouring of the Greek Court in the Crystal Palace, with a Fragment of the Origin of Polychromy by Gottfried Semper* (1854), and *The Grammar of Ornament* (1856). This last book constitutes an extraordinary source of historical color designs, systematically arranged and covering different geographies and periods, from the ancient times to the early 17th century (Fig. 6). In the introduction, Jones describes the principles for the arrangement of form and color.<sup>8</sup>

John Ruskin (1819–1900), the theoretician who exerted a strong influence on the architects and designers of the

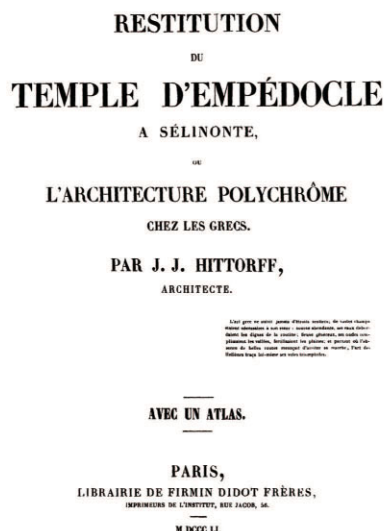


FIG. 5. Jacques-Ignace Hittorff (1792–1867), the front page of the first edition of *Restitution de Temple d'Empédocle à Selinonte* (Paris, 1851) and the chromatic reconstruction of the Greek temple.



FIG. 6. Owen Jones (1809–1874), one of the plates from *The Grammar of Ornament* and a view of the Crystal Palace.

arts-and-crafts period, as well as on the pioneers of modern architecture, included interesting considerations about color in his famous book *The Seven Lamps of Architecture* of 1849 (Fig. 7). In the chapter “The Lamp of Truth,” he advocates the use of materials in their natural colors, without resorting to the use of paints (a tenet that would be followed in the 20th century by the organicist and brutalist trends of modern architecture). In the chapter “The Lamp of Beauty,” he conceives sculpture without color, that is, monochrome, but he cannot envision architecture in the same way. He speaks of architecture as an organic being and encourages the use of color through the observation of nature.<sup>9</sup>

Some of the most important historians of architecture have dedicated sections to the use of color in different periods. In 1875, Eugène-Emmanuel Viollet-le-Duc (1814–1879) published a history of the human dwelling, in which he consistently includes sections to describe the use of color in houses, palaces, villas, and all kinds of family dwelling architecture in ancient China, Egypt, Assyria, Greece, during the Roman Empire, in the Middle Ages in Europe, and also in the ancient Muslim world. In the Appendix of the book, he includes four colored plates depicting the interior of an Egyptian house, a house in Athens in the 5th century

B.C., a Roman palace, and a room in a feudal castle (Fig. 8).<sup>10</sup>

In his famous *History of Architecture* of 1899, Auguste Choisy (1841–1908) dedicates a section with a specific heading about color in every chapter, reviewing the use of color in the architecture of Ancient Egypt, Chaldea and Assyria, India, China and Japan, as well as the pre-Hellenistic and the Greek architecture.<sup>11</sup> Despite the fact that none of these historians provide precise details about their sources, and we cannot be sure about the accuracy of their assertions, their words and drawings are probably the only sources now available to us to attain some knowledge about the colored environments of the ancient past.

More recently, the South-African architect Rex Distin Martienssen (1905–1942), in his Ph.D. thesis of 1941 on *The Idea of Space in Greek Architecture*, conducted a detailed research about the polychromy of the Greek temples (Fig. 9).<sup>12</sup> His sources were his own direct examination of the ruins, and the writings of L. Magne (1895), A. Choisy (1899), M. L. D’Ooge (1908), G. Dickins (1912), P. Gardner (1921), F. Poulsen (1920), and D. S. Robertson (1929, 1932). Curiously, he does not mention the pioneering studies by Hittorff.

As an addition to this section on historical and archeological research on color, we can refer to the paper by Karin Fridell Anter (1950–) about Pompeiiian colors, presented as invited lecture in one of the Symposia on Environmental Color Design in AIC 2005, the 10th Congress of the International Color Association.<sup>13</sup> The main contribution of this paper is that it focuses on the colors of the cityscape, a subject far less studied than the colors of Pompeii’s interiors. From the methodological point of view, the remarkable aspect is that Fridell Anter employs a broad set of documentation sources—reports from the first excavations, texts that describe the pigments used by the time when Pompeii flourished, artistic reproductions of the city, an archeological model exhibited in Naples, as well as her own inspection on site—with which she is reconstructing, as pieces in a puzzle, a coherent understanding of color in that ancient Roman city.

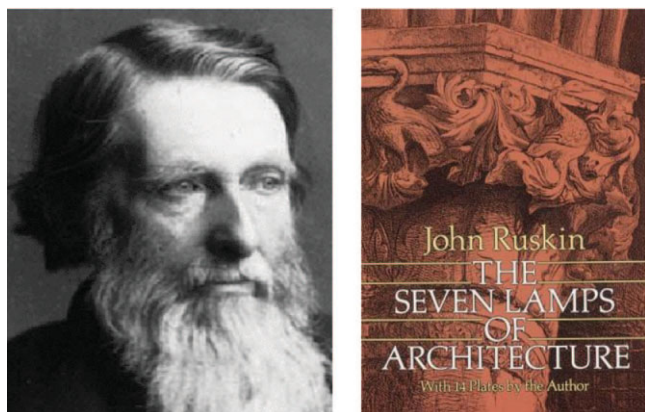


FIG. 7. John Ruskin (1819–1900) and the cover of a modern edition of *The Seven Lamps of Architecture*.



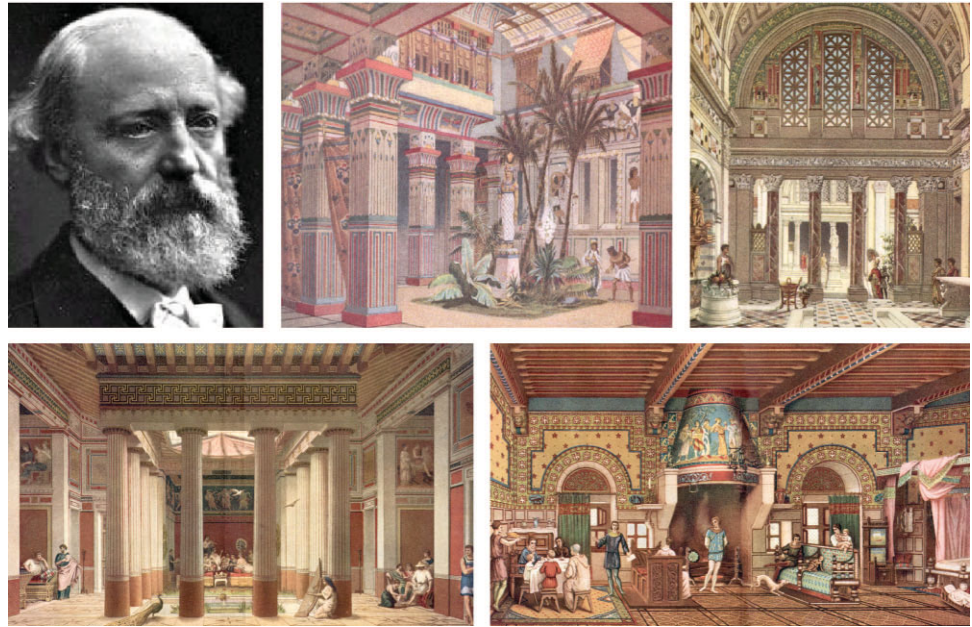


FIG. 8. Eugène-Emmanuel Viollet-le-Duc (1814–1879) and his chromatic reconstructions of the interiors of an Egyptian house, a Roman palace, a Greek house, and a feudal castle.

## ARCHITECTS OF THE 20TH CENTURY

Let us now move on to the practicing architects who worked in the early 20th century and are considered the masters of modern architecture, and let us examine their conception of color. The most outstanding figure we can find in this context is Le Corbusier (1887–1965). His first writings on color appear in the articles about purism and cubism written in collaboration with the painter Amédée Ozenfant. An article of 1918 reads:

The idea of form precedes that of color. The form is preeminent, color is but one of its accessories. Color depends entirely of the material shape: the concept of sphere, for instance, precedes the concept of color; it is conceived as a colorless sphere, a colorless plane, color is not conceived independently of some support. Color is coordinated with form, but the reciprocal is not true.

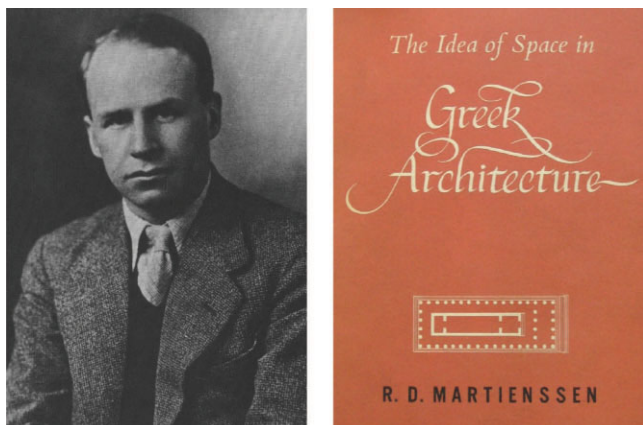


FIG. 9. Rex Distin Martienssen (1905–1942) and the cover of his book on Greek architecture.

We believe, thus, that a theme should be selected for its forms and not for its colors.<sup>14</sup>

Some other articles published in 1921, 1923, and 1924 in the journal *L'Esprit Nouveau*, proceed more or less in the same vein, that is, denying any importance that color might have in the construction of space in painting.<sup>15</sup> The curious fact is that a few years later, in his writings on architectural polychromy of 1931, Le Corbusier seems to have changed his mind completely, to the extent of quoting and agreeing with Fernand Léger, who said: “Man needs colors to live, it is an element as necessary as water and fire.” In addition, Le Corbusier describes examples of his own use of color in order to drastically change the spatial perception of architecture, as in the neighborhood designed and built in Pessac (Fig. 10).<sup>16,17</sup>

In his monograph written for the exhibition of the *Pavillon des Temps Nouveaux* in 1937, Le Corbusier includes a chapter entitled “Polychromy = Joy,” in which he associates the creative ages of architecture with the vitality of chromatic color and relates the stagnant academicism to sad gray (Fig. 11).<sup>18</sup> At this point, it should be noted that there is a discrepancy regarding this matter with other advocates of modern architecture who associate color with the decoration and ornament of traditional architecture, as opposed to the white purity that modern architecture should exhibit. It seems that in both his theories and his works, Le Corbusier evolved toward a more conscious and thorough consideration of the power color has to modify the spatial environment. This is especially evident in the buildings projected and built after World War II, in what is called his “brutalist” period.

The importance that Walter Gropius (1883–1969)—another of the masters of modern architecture—gave to color studies is clearly shown in the programs for the Bauhaus school (Fig. 12) and in some of the professors that were

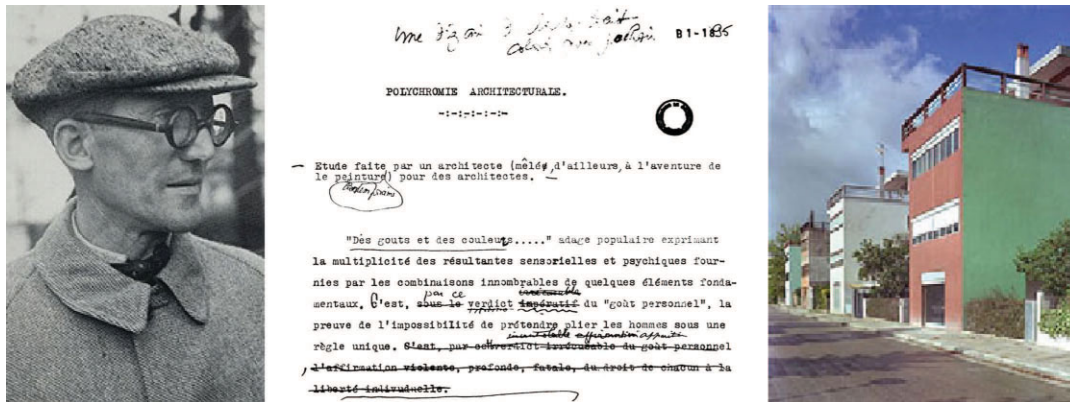
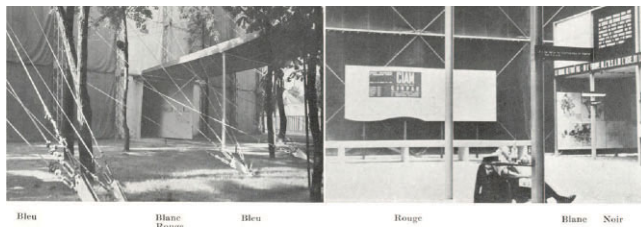


FIG. 10. Le Corbusier (1887–1965), a fragment of his text on architectural polychromy, with handwritten corrections (from Fondation Le Corbusier), and a view of the houses in Pessac, built in 1925.

selected to teach there: Wassily Kandinsky, Paul Klee, Josef Albers, and Johannes Itten, among others.<sup>19</sup> In his book *Scope of Total Architecture* (1956), when dealing with the education that architects and designers should receive, Gropius includes sections about “The Language of Vision,” “Some Biological Facts about Our Way of Seeing,” “Optical Illusions,” and “Psychological Influence of Shapes and Colors.”<sup>20</sup>

The Dutch neoplasticist movement, organized by 1917 around the publication *De Stijl* and stemming from the abstract paintings of Piet Mondrian, helped to create a better consciousness about color theory and practice,<sup>21</sup> introducing color as determinant of space, in opposition to its traditional decorative function. However, this movement produced no important achievements in the field of architecture and design, except for a few works by Theo van Doesburg (1883–1931)—the cabaret Aubette; Jacobus Johannes Pieter Oud (1890–1963)—the restaurant De Unie; and Gerrit Rietveld (1888–1964)—the Schröder house, his famous chair, and a few more designs. Of these examples, only Rietveld managed to make a true spatial organization of color and planes, while the others continued to produce two-dimensional transpositions of the neoplasticist elements of painting to architecture (Fig. 13). The influences were exerted



## POLYCHROMIE = JOIE

La couleur éclate spontanément aux époques créatrices, démente fait gris.  
Tous les âges ont employé la couleur (Égypte, Assyrie, Moyen âge). La couleur a été maintenue magnifiquement, égal aux âges d'apparat (Louis XIV), aux premières manifestations de l'architecture intimiste (Louis XV). La couleur fait partie intégrante de la sensibilité humaine. Elle représente une puissance architecturale immense dont on a perdu l'emploi aujourd'hui, après ce siècle décadent que nous venons de traverser.



FIG. 11. Le Corbusier: page on polychromy and colored reproduction of the Pavilion of the New Times.

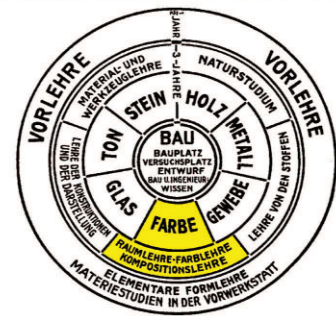


FIG. 12. Walter Gropius (1883–1969) and the Bauhaus: the building in Dessau, a poster, and the divisions of the curriculum, where color studies occupy 1/7 part of the total.



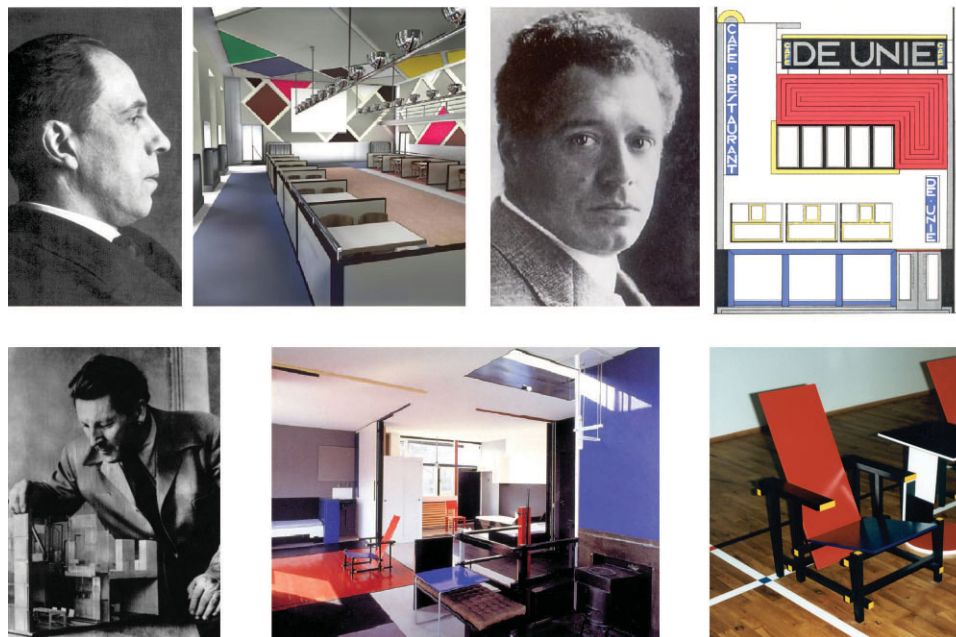


FIG. 13. Van Doesburg and the colors in the cabaret Aubette; Oud and the facade of the restaurant De Unie; Rietveld, the interior of the Schröder house, and the chair.

more through the theoretical manifestos and the imagery of projects, drawings, and maquettes than through actual buildings.

By far the boldest and most outstanding colorist among the architects of the modern movement was Bruno Taut (1880–1938). Even when he is not deemed as eminent as Le Corbusier, Gropius, Mies van der Rohe, or Wright, because his influence on the next generations was not as strong as theirs, Taut was the one who advocated for the use of color the most. The audacity of Taut's color schemes led Le Corbusier to say in 1927: "My God, Taut is color-blind!" Commenting about the impact caused by his Falkenberg housing estate of 1915 in Berlin-Grünau, Taut himself declared that his color scheme "provoked the Berliners who, coming from the gray tenement quarters, repeatedly declared that the architect deserved to be locked up" (Fig. 14). Among his many writings, the vast majority of which are only in German and not easily available and which are worthy of a wider dissemination, in 1919 Taut published a "Call for Colorful Architecture," which was cosigned by Walter Gropius, Peter Behrens, Hans Scharoun, Max Taut, Hans Poelzig, Fritz Schumacher, Otto Wagner, and others.<sup>22</sup>

We can note a series of curious and apparent contradictions in the positions in favor or against architectural polychromy among the architects of the modern movement during the first half of the 20th century. The modern movement reacted against the academicist architecture of the 19th century, which was attacked, among other aspects, "for its lack of color" by some architects, as well as "for using color" by others. On one side, Taut and his followers criticize the architecture of the past for its monochromatic and sad aspect:

The 19th century . . . paying attention to its general characteristic features, is dominated by a thought which is not productive or joyful of life, and is marked

by the face of grayness and paleness, instead of being enhanced with a vivid redness.<sup>23</sup>

On the other side, the promoters of purism, rationalism, and what would later be known as the "international style" in modern architecture, consider that color, regarded as a decorative element, is linked to the architecture of the past and to regionalisms. The new architecture should refrain from decoration or ornament. Thus, they tried to differentiate from the past by producing a white and purist architecture with no geographical markers. César Pelli, the Argentine architect who, living and working in the United States, has acquired international recognition, describes the situation in the 1940s:

When I was a student of architecture in Tucumán, Argentina, I learned that proper, serious Modern architecture should have no colour except for the colours of natural materials, whites or greys—anything else was frivolous or decadent. In the years after the Second World War, students of architecture in progressive schools all over the world must have learned the same lessons.<sup>24</sup>

However, we can see that another way of addressing this controversy is possible: Much of the discussion among modern architects with regard to the conception and use of color can be considered in connection with the different modes of dealing with color, instead of being established between the detractors and the defenders of color. A milder view would show that even those who were very austere or purist in this sense (like Gropius or Mies, for instance) did not ignore the importance of color. The color white in the most purist modern architecture was intended to make the building contrast with the environment, or to make the details or furniture in the interiors stand out, or to let the





FIG. 14. Bruno Taut (1880–1938) and some of his colorful houses.

chromatic weight of the landscape penetrate with more strength into the interiors through the large surfaces of glass or the horizontal windows. The followers of the organicist architecture (whose paradigm is Frank Lloyd Wright), supporters of not covering surfaces with paints but leaving the materials to express their inherent color, were not less aware of the value of color.

For those who wish to go deeper into the complex aspects and variations of color in architecture in the first half of the 20th century, and especially in the 1920s, there is an excellent monograph by Maurice Besset.<sup>25</sup>

The postmodern reaction of the 1970s and 1980s brought about a host of architects concerned with the references to history and to the environment, and color in architecture also acquired a new meaning under these orientations. As examples, we can mention the works by Charles Moore, Robert Venturi, Michael Graves, and Stanley Tigerman (in the United States), Paolo Portoghesi and Aldo Rossi (in Italy), Aldo van Eyck (in the Netherlands), and Mario Botta (in Switzerland).

As for the 1990s, in the book on *Color in Architecture* by Harold Linton (1947–) we can find a good account of the works by architects and colorists of the more recent generations, who mainly act as color consultants: Jean-Philippe Lenclos (France), Tomás Taveira (Portugal), Shashi Caan and Donald Kaufman (the United States), Begoña Muñoz (Spain), Eva Fay (Australia), Lourdes Legorreta (Mexico),

Malvina Arrarte (Peru), Shingo Yoshida (Japan), Giovanni Brino (Italy), Michael Lancaster (UK), and Leo Oberascher (Austria), among them.<sup>26</sup> These works encompass not only color projects for new buildings but also color restoration of historical urban centers, landscape color plans, and models developed for color research and education in architecture. The specificity of the knowledge about color in environmental design has given rise over the past decades to a new profession: the color consultant, who can work in collaboration with other architects or designers or be hired for special projects by companies and private or governmental agencies. In her articles about this topic, Sonia Prieto mentions various renowned color consultants who have worked over the past years in France: Jacques Fillacier (1913–1986), Georges Patix (1920–1992), Fabio Rieti (1927–), Bernard Lassus (1929–), Jean-Philippe Lenclos (1938–), France Cler (1940–), and Michel Cler (1938–). Some of them are also authors of publications with theoretical insights.<sup>27,28</sup>

In order to finish this section on color in architecture in the 20th century, apart from the previous chronological sequence, and making a geographical move to Latin America, I want to mention three cases of recognized masters of architecture that are paradigmatic for the conception and application of color: Carlos Raúl Villanueva (Venezuela), Luis Barragán (Mexico), and Clorindo Testa (Argentina). The most famous work by Villanueva (1900–1975) is un-

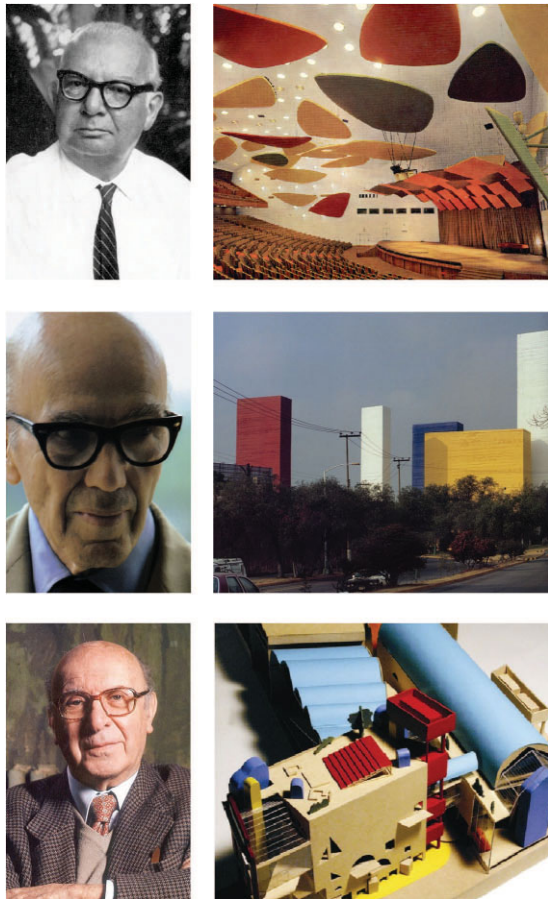


FIG. 15. Carlos Villanueva, Luis Barragán, and Clorindo Testa, beside examples of their architecture in Caracas, Mexico City, and Buenos Aires, respectively.

doubtedly the University Campus in Caracas, an architectonic complex that in the year 2000 was declared cultural heritage of mankind by UNESCO, in which polychromy plays a key role.<sup>29</sup> Luis Barragán (1902–1988), a Mexican colorist who has created spaces of great expressiveness, was the second architect, after Philip Johnson, being awarded the Pritzker Prize (the equivalent to a Nobel Prize in architecture) in 1980. Clorindo Testa (1923–), who was born in Italy but studied and built his whole career as an artist and architect in Argentina, began at the early stages of his professional work to develop a kind of architecture influenced by Le Corbusier's brutalist period, but soon evolved toward a very personal and original treatment of the spatial configurations and color. In 2005, at the age of 82, he is still considered a living master who keeps renovating himself constantly and constitutes a source of inspiration for the young generations (Fig. 15). The verbal discourses about color of these architects, however, are usually less salient than their concrete chromatic and spatial configurations.

#### ARCHITECTS WHO HAVE DEVELOPED COLOR ORDER SYSTEMS

Among the contributions to color theory coming from the field of architecture, I would like to mention a few particular

cases of architects who have been involved in the development of color order systems.

The English architect William Benson published in 1868 a book entitled *Principles of the Science of Colour*, where he makes a historical review of color studies and presents a color order system organized in a cubic shape, which seems to be the first of this kind in the chronology of color order systems.<sup>30</sup>

The Argentine architect Julio Villalobos (1905–?) was coauthor, together with his father, Cándido Villalobos Domínguez (1881–1954), of the *Colour Atlas*, published in Buenos Aires in 1947. This atlas, organized in a system with an hexagonal prismatic shape, includes 7279 printed color samples and was at the time of its appearance the larger systematic color collection ever published (Fig. 16).<sup>31</sup>

The Swedish scholar Sven Hesselgren (1907–1993) was a color theorist and a practicing architect. Early in his career, he tried to put into practice the color harmonies developed by Ostwald by applying them in a project for a hospital. According to his own words, the results were “terrifying.”<sup>32</sup> Later on, he developed a color order system that was one of the antecedents that gave origin to the Natural Color System (Fig. 17).<sup>33,34</sup> These two facts alone show to what extent he was interested both in doing color research and in testing research findings in the architectural practice. Furthermore, in his book *The Language of Architecture*, Hesselgren devotes several chapters to color and presents an early attempt at developing a graphic representation of a color order system which comprises the modes of appearance described by David Katz. This model could be regarded as a normal three-dimensional color space moving along a two-dimensional plane, thus comprising five dimensions.<sup>35</sup>

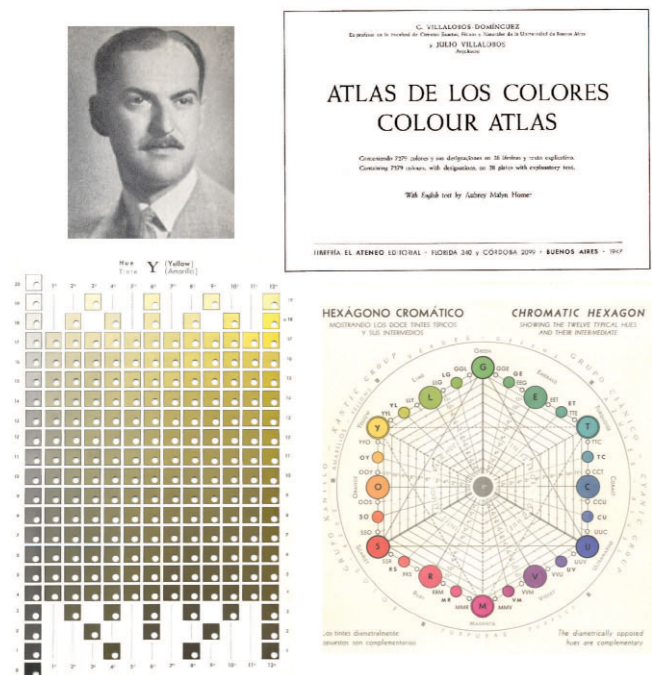


FIG. 16. Julio Villalobos (1905–?), the front page of *Atlas de los Colores*, published in 1947, the chromatic hexagon, and a page of constant hue from the atlas.



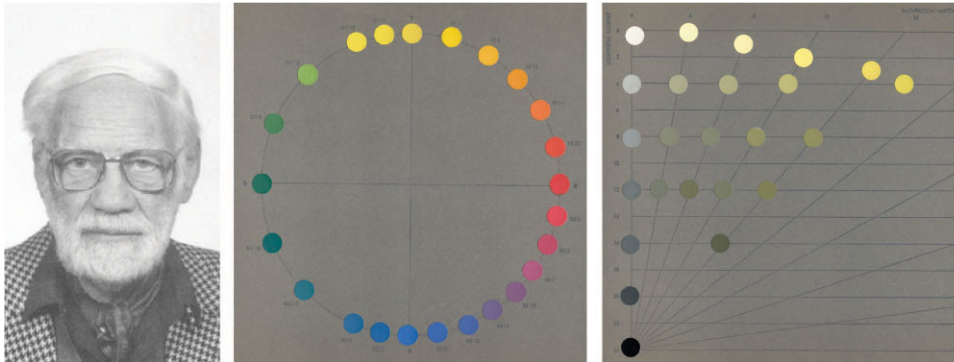


FIG. 17. Sven Hesselgren (1907–1993), the chromatic circle, and a plane of constant hue from his *Colour Atlas* of 1953.

Hesselgren was one of the theorists whose ideas exerted a strong influence on the Argentine architect and professor César Jannello (1918–1985), who invented the term “cesia” to encompass visual perceptions such as gloss, transparency, translucency, etc., which can be regarded either as different modes of appearance of color or as composing a separate set of visual variables, complementing color.<sup>36</sup> The variables of cesia and the three-dimensional model for their representation were later developed and systematized by the author of the present article.<sup>37</sup>

In the next section we will see some other contributions to the development of color order systems related to environmental design.

#### RESEARCH ON ENVIRONMENTAL COLOR DESIGN IN RELATION TO THE AIC

Having provided an overview on the first theorists of architecture who dealt with color, on some of the historians of architecture who included color in their studies, on some of the research and application of color in the architecture of the 20th century, and on some of the architects who contributed to the development of color order systems, I want to present a short account of what has been researched on color in architecture and design over the most recent years, after the foundation of the International Color Association (AIC, Association Internationale de la Couleur) and the participation of many specialists working in these areas in the AIC meetings. As it is impossible in this article even to mention all the authors that have contributed to the development of color theories or applications related to architecture and design, I will present a rather arbitrary selection mostly based on my personal knowledge of the people involved. I will just refer to a few pioneers and to some of the people who have been connected with the Environmental Color Design (ECD) Study Group of the AIC.

Sven Hesselgren, already mentioned in the previous section, was also involved in activities in relation to the AIC. He participated in the AIC Forsius Symposium on Color Order System in 1983, delivering one of the invited lectures.<sup>38</sup>

The contributions by Antal Nemcsics, Anders Hård, Lars Sivik, Werner Spillmann, and other past and present members of the ECD Study Group to its own constitution and

development have been highlighted in a paper presented at AIC 2002, in Maribor, Slovenia.<sup>39</sup> As for the scientific aspect, Nemcsics and Hård’s main achievements have been without doubt the development of two color order systems that are very useful in architecture and design. Antal Nemcsics (1927–) is the author of the Coloroid system, which has the unique feature that its scales are homogeneous from the aesthetic point of view and the interesting characteristic that it includes in the same model both the boundaries for all perceptible colors and the boundaries for the set of surface colors.<sup>40,41</sup> Anders Hård (1922–), who in 1997 received the AIC Judd Award, was the main responsible for the development of the Natural Color System on the grounds of Ewald Hering’s theory of color opponency.<sup>42,43</sup> Today, the NCS is perhaps the most used color order system in architecture and design. Werner Spillmann (1933–) has worked both as a color consultant in architecture projects and as a theorist. He delivered the opening lecture of AIC 1989, precisely on the topic of color in architecture and design.<sup>44</sup> Among other aspects of his research interests, his knowledge about ancient and modern color order systems is paramount.<sup>45,46</sup>

Giovanni Brino was a pioneer in developing color plans and methodologies of color restoration in historical centers, as well as in setting up a school of urban restoration in Turin. I would just like to quote from his invited lecture at the AIC 1993 congress in Budapest: “The ‘colour plan of Turin’, carried out by the writer between 1978 and 1983, represented the first attempt in Italy at a rational response to the problem of restoring façades on a city-wide scale, on the basis of objective historic documentation.”<sup>47</sup>

Shigenobu Kobayashi (1925–), working at the Nippon Color & Design Research Institute, has developed a color image scale, a fundamental instrument that links image words to color combinations. This is clearly a device connecting a systematic psychological research on color meanings with applications in design.<sup>48,49</sup>

Lars Sivik (1933–) received the AIC Judd Award together with Anders Hård and Gunnar Tonnquist in 1997. Coming from the field of psychology, Sivik’s whole career in color research has always been linked to environmental color design. His fields of interest range from color order systems (he was deeply involved in the development of the

NCS) to color meaning associations and color combinations.<sup>50-53</sup>

Of the color consultants who have been working in France in the past years, mentioned before, Michel Cler (1938–) is the one who most actively has participated in AIC meetings since 1991.<sup>54-56</sup> Regarding professional work, the Atelier France and Michel Cler carried out chromatic urban projects not only in France but also in Hong Kong, Vietnam, and the Antilles.

Theano Fanny Tosca (1955–) has worked mainly on semiotic aspects of color in architecture and urban spaces and has developed color rehabilitation projects in Greece.<sup>57-59</sup>

Leo Oberascher (1955–) wrote his Ph.D. thesis on color and cognitive psychology and has been working as color consultant in architecture and design for decades. His real-scale models that explore the realms of color, texture, cesia, and other aspects of appearance can be considered both an educational tool and a source for testing spatial configurations applicable to architecture.<sup>60,61</sup> In the AIC, he has been a prominent figure in nearly every congress since 1987, and he has chaired the ECD Study Group.

Paul Green-Armytage (1939–) possesses great expertise in teaching color to students of design and has presented his ideas in most of the AIC congresses since 1981, as well as in other meetings and publications. The most salient aspects of his work, from my point of view, are the call for the development of a color language that can be shared in all fields of color research and education and his efforts to promote bridges between the findings in color science and their application in design.<sup>62-65</sup> Precisely, his paper on “Colour Science for Colour Design” presented as an invited lecture in one of the ECD Symposia in AIC 2005, Granada, is very enlightening in this regard.<sup>66</sup>

Lucia Ronchi (1927–), former president of the AIC during the 1994–1997 term, has always shown a great interest in the studies on color and the environment and contributed with related papers in various AIC meetings, with a glossary of terms, and conveying the research on color vision that could be useful in the field of design.<sup>67-69</sup>

The most recent laureate with the AIC Judd Award, John Hutchings (1932–), is a physicist with interdisciplinary interests, who has worked mainly on color in food, appearance, color in folklore, and environmental color design. A remarkable contribution to the links between color science and design was made in a couple of articles entitled “The Continuity of Color, Design, Art, and Science,” published in *Color Research and Application*.<sup>70</sup> He has also traced links between color appearance in food and design.<sup>71,72</sup> It is an honor for the ECD Study Group to have him among its members. A former and somehow shorter version of his Judd Award lecture presented in AIC 2005 was about design ethics in the use of color in food marketing and was originally intended for one of the ECD symposia in the same congress.

The use of spectrophotometric techniques for color measurement and of standardized samples from color order systems for classification and specification purposes appears

today as a necessity in studies of colors, color plans, and projects of rehabilitation or restoration of historical buildings and urban districts, offering the possibility of constituting accurate color-data banks. Some of these methodologies can be seen applied, for instance, in the works by Angela García Codoñer (1944–) in Valencia, Spain,<sup>73</sup> María Mercedes Avila (1944–) in Córdoba, Argentina,<sup>74,75</sup> and Grete Smedal (1937–) in Norway,<sup>76</sup> just to make reference to members of the ECD Study Group or participants in AIC 2005.

A number of researchers of environmental color design have been employing experimental methodologies (derived mainly from the research in psychology, psychometrics, and psychophysics) in their studies. I would just like to mention an outstanding case in the ECD group: Monica Billger (1961–).<sup>77,78</sup>

Today, the ECD Study Group is a truly interdisciplinary network, with members coming from various different fields, such as architecture and urban studies, textile design, graphic design, fine arts, history, physics, optics, vision, psychology, ecology, and engineering.

## CONCLUSIONS AND PROSPECT OF THE IDEAL FUTURE

To conclude, let us summarize the main characteristics of the conceptions of color reviewed so far. The focus of the discourses about color in the architectural treatises from the ancient times until the Renaissance seems to have been put on the material aspects: pigments and their mixtures. As for the discourses of the historians and archeologists of the 19th century, they are mainly descriptive of the use of color in the past, with a pretension of objectivity. Among the modern architects of the 20th century we can find two kinds of discourse: (a) the architects who write in a didactical way, giving importance to color studies and appealing to color science (like Gropius), usually do not make a special use of color in their projects or buildings; (b) the architects who have produced polychrome architecture usually write about color in a rhetorical way (like Taut), trying to convince rather than educate or convey information or knowledge about color. Finally, among the color researchers who come from the field of architecture and design and have been related to the International Color Association, I want to highlight those who try to build common grounds between color science and color design.

I have no doubts that the evolution in the use of color in environmental design in the future, and thus the research in this field, will have to rely more and more on a fruitful interaction between scientists and designers. The surveys conducted by Jan Janssens and Byron Mikellides on color in architectural education show that there is a severe lack of knowledge about color research among students of architecture.<sup>79,80</sup> This situation must be reverted. In this sense, the most important task for the researchers of environmental color design will be to act as a nexus between both groups, developing applications of color science in color design, proposing theoretical hypotheses that could be scientifically



tested, and contributing to the mutual communication by agreeing on terminological matters based on common grounds. In my view, the most interesting scenario we can desire and expect in the years to come is a true integration of all fields of color research and the sharing of a common language. This has been one of the main goals of the International Color Association since its creation in 1967. In view of this, I would like to finish by quoting Paul Green-Armytage in his lecture for the closing session of AIC 2001:

In the future that I hope for there will be more interaction between the arts and sciences in the field of color. Artists and scientists each have their own way of contributing to knowledge. I hope we can encourage more artists to join the designers and architects in the AIC. [...] I was struck by an instance during the congress where an artist and a scientist had come to similar conclusions, but through their own distinct ways. [...] If there is to be more cooperation between the disciplines, between people in the sciences and the humanities, and if that is to be productive, a first move might be to tackle the thorny problem of terminology. It will be a good way to start if we can learn to speak each other's color languages.<sup>81</sup>

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