COLOR IN HEALTHCARE ENVIRONMENTS

ruth brent tofle ▪ benyamin schwarz ▪ so-yeon yoon ▪ andrea max-royale

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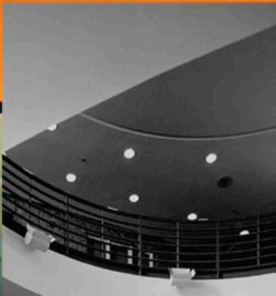

Coalition for Health Environments Research

Color In Healthcare Environments - A Research Report

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Sponsor: Coalition for Health Environments Research (CHER)

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COLOR

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By

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"Authority of color is captured when embedded in its milieu".

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ABSTRACT

The purpose of this study was to review the literature on color in healthcare environments in order to separate among common myths and realities in the research and application of color in healthcare design. Utilizing online searches of existing bibliographies and databases in multiple disciplines, we reviewed more than 3000 citations to identify theories, which could have had supportable design implications for the use of color in healthcare design. We sought to determine which issues and concepts in the literature might contribute to the knowledge of architects, interior designers, researchers, healthcare providers, and users of healthcare environments.

Color is a fundamental element of environmental design. It is linked to psychological, physiological, and social reactions of human beings, as well as aesthetic and technical aspects of human-made environments. Choosing a color palette for a specific setting may depend on several factors including geographical location, characteristics of potential users (dominant culture, age, etc.), type of activities that may be performed in this particular environment, the nature and character of the light sources, and the size and shape of the space.

The evidence-based knowledge, however, for making informed decisions regarding color application has been fragmented, sporadic, conflicting, anecdotal, and loosely tested. Many healthcare providers, designers and practitioners in the field have questioned the connections between color and behavior of people, suspected the value of color as a psychotherapeutic aid, and searched for empirical reasoning for the various color guidelines in healthcare settings.

The results of the critical review of the pertinent literature produced no reliable explanatory theories that may help to predict how color influences people in healthcare settings. Regrettably, much of the knowledge about the use of color in healthcare environments comes from guidelines that are based on highly biased observations and pseudo-scientific assertions. It is this unsubstantiated literature that serves color consultants to capriciously set trends for the healthcare market.

The collective lessons of the numerous studies reviewed in this manuscript can be summarized in the following:

1) There are no direct linkages between particular colors and health outcomes of people. No sufficient evidence exists in the literature to the *causal* relationship between settings painted in particular colors and patients' healthcare outcomes.

2) Specifying particular colors for healthcare environments in order to influence emotional states, or mental and behavioral activities is simply unsubstantiated by proven results. It is not enough to claim what color can do for people; it is important to distinguish between the explicitly stated aim of such assertions and their latent function. Spaces do not become "active", "relaxing", or "contemplative" only because of their specific color.

3) There are demonstrable perceptual impressions of color applications that can affect the experience and performance of people in particular environments. There are indications in the research literature that certain colors may evoke senses of spaciousness or confinement in particular settings. However, the perception of spaciousness is attributed to the brightness or darkness of color and less by its hue. The sense of spaciousness is highly influenced by contrast effects particularly brightness distinctions between objects and their background.

4) While studies have shown that color-mood association exists, there is no evidence to suggest a one-to-one relationship between a given color and a given emotion. In spite of contradictory evidence, most people continue to associate red tones, for example, with stimulating activities, and blue tones with passivity and tranquility. Clearly, colors do not contain inherent emotional triggers. Emotional responses to colors are caused by culturally learned associations and by the physiological and psychological makeup of people.

5) The popular press and the design community have promoted the oversimplification of the psychological responses to color. Many authors of color guidelines tend to make sweeping statements that are supported by myths or personal beliefs. Likewise, most color guidelines for healthcare design are nothing more than affective value judgments whose direct applicability to the architecture and interior design of healthcare settings seems oddly inconclusive and nonspecific. The attempt to formulate universal guidelines for appropriate colors in healthcare settings is ill advised. The plurality, or the presence of multiple user groups and subcultures, and the complexity of the issues of meaning and communication in the environment make efforts to prescribe universal guidelines a futile endeavor. Consider, as an example, the issue of weak communication in the context of color specification in present healthcare settings: designers may attempt to endow the settings with cues that the users may not notice. If the users notice the cues, they may not understand their meaning, and even if they both notice and understand the cues they may refuse to conform as predicted.

6) The study of color in healthcare settings is challenging because it occurs in the context of meaningful settings and situations. When people are exposed to a color in a certain setting, their judgment is a result of a reciprocal process that involves several levels of experience. People first acquire direct information through their visual perception. This input is analyzed against their background of cognitive information regarding that environment and that particular color which they have obtained from their culture. The consequence of this process is dialectical because cultural standards modify perceptions and these perceptual inputs, in turn, modify a human's aesthetic response.
   But this process does not take place in a vacuum. It occurs within a web of experiential conditions, which inevitably modify people's judgmental processes. Thus, if the healthcare setting is too noisy, or too cold, or the place is cluttered with an array of medical equipment and bad odors, the aesthetic experience of an individual's response to its color will be affected, regardless of its "objective" meaning. In addition, the response is influenced by the person's role in the settings (whether he or she is a patient, a staff member or a visitor to the facility). Furthermore, a large host of internal forces are involved in the act of reaching aesthetic conclusions. Among them are the person's physical condition (whether he or she feels sick or suffers from pain, how tired he or she is, whether he or she lays in bed or works out as part of their physiotherapy, etc.) as well as the person's psychological state (whether he or she is aware of his or her surroundings or he or she is under the influence of drugs, or anxious about medical procedures, or suffers from dementia, etc.).

In conclusion, we want to reiterate that currently the use of color in healthcare settings is not based on a significant evidence-based body of knowledge. Second, we suggest that the attempt to formulate universal guidelines for appropriate colors in healthcare settings is ineffectual. The multiple user groups and subcultures, and the complexity of the issues of meaning and communication in the healthcare environment make the efforts to prescribe universal guidelines an unproductive undertaking. Our efforts need to concentrate on the particular through the formulation of explanatory theories and empirical studies with the aim to give attention to specific and concrete problems rather than abstract and universal questions.

Clearly, the research of color in healthcare environments is an important endeavor. Yet, the subject matter is complex and multifaceted. Furthermore, mastering this knowledge for the application of research findings in healthcare settings requires caution and sensitive creativity is paramount.

INTRODUCTION

Color is a fundamental element of environmental design. It is linked to psychological, physiological, visual, aesthetic, and technical aspects of human-made environments. Choosing a color palette for a specific setting may depend on several factors: the geographical location; the characteristics of the potential users, their dominant culture, age, etc.; the nature and character of the light sources; the size and shape of the space; and the type of activities that are performed in this particular environment.

The growing interest in research-based knowledge for the application of color in healthcare design led to this project. It has been prompted and funded by the Coalition for Health Environments Research (CHER), who has rightly observed that the evidence-based knowledge for making informed decisions regarding color application was not readily available. CHER noticed that while healthcare providers and practitioners in the field have searched for empirical reasoning for color guidelines, healthcare designers continue to make decisions concerning color with unsubstantiated knowledge.

As a rule we are fascinated with science and its contribution to the understanding of our world. The tendency to justify decisions, such as color selection in healthcare facilities, by employing scientific explanations is, perhaps the rationale that generated the funding for this project. A recent article in the Wall Street Journal regarding the impact of décor and layout on hospital patients is quite revealing:

> There is no question in my mind that a calming, healing environment helps patients deal more effectively with their pain", says Michael Henderson, a physician and chief medical officer at the institute.
>
> The idea that building's layout, furniture and décor influence patients' medical experience isn't new. "It's something we innately felt, " says Debra J. Levin, executive vice president of the Center for Health Design, a nonprofit group for designers, health-care executives, and product manufacturers in Pleasant Hill, Calif. The problem, she says, was "there was nothing out there to hang your hat on." Hospital executives were saying, "if you want funding, you need to prove to me that if you do X, you'll make Y happen. I can't just trust you with my $20 million on a handshake (Rich, 2002).

The main intention of this monograph has been to review the existing research literature on the relationship between people and color in the environment with special emphasis on the design of healthcare environments. The knowledge base has been fragmented, sporadic, conflicting, anecdotal, and loosely tested. Thus this study has been an attempt to separate common myths and realities in color studies. From the onset of this project we made an attempt to answer two fundamental questions:

1. What is empirically known about human response to color and how, if at all, color influences human perception or behavior in a specific setting?
2. Which color design guidelines for healthcare environments, if any, have been supported by scientific research findings?

This monograph strives to cover issues and concepts that are important to scholars in the field; architects, interior designers, and healthcare providers; and, users of healthcare environments. While the reference guide does not cover all aspects of color, it allows the reader to make intelligent comparisons among various contexts and discipline perspectives and to continue the learning process based on the referenced sources. We hope that the monograph will play a stimulating role in the advances of color studies for the built environment, and more specifically in the design of healthcare settings .

METHODS

Utilizing online searches of existing bibliographies and databases in multiple disciplines, systematic research was conducted. In addition, resources from color industries that were made available to the public were examined to the extent possible.

We focused our search for resources that made a direct connection between color and the healthcare environment. The challenge was to decide which fundamental color theories should be included in a reference guide for healthcare practitioners interested in color for their particular domain. As we went through the literature we asked ourselves whether there were any predominant theories that must be included in the discussion as opposed to other theories, which should be excluded.

Over 3000 titles were scanned for information on color theory, research, and resources for the healthcare industry. Databases such as PsychINFO, Avery Index, WorldCat, HealthSource, HealthSTAR, as well as Internet search engines including LookSmart, MSN, Google, and Yahoo, were searched for references on the topic. Available copies of the literature were reviewed, seeking to evaluate the information for empirically based evidence of the service of color to the health field. Unfortunately, citations in languages other than English were not included in our report.

Following the compilation of the bibliographic list we issued the first draft of the report, which was submitted to an expert panel of leading designers in healthcare design and primary scholars in the field of color. The monograph was revised based upon the expert panel members' comments.


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1 2 Kaiser Permanente, Townpark Clinic
Kennesaw, Georgia
Architect: *Perkins & Will, 1998*

BACKGROUND

The Nature of Color

Color has been described as a subjective visual sensation produced by light. Sir Isaac Newton observed in the late 17th century that a beam of white light contains all visible color, and it could be separated into a spectral band of various hues. Newton distinguished among seven hues: violet, indigo, blue, green, yellow, orange, and red (VIBGYOR). According to one explanation Newton arbitrarily assigned seven hues to the spectrum, parallel to the seven notes of the musical scale. Although he was aware that there were many more colors in the spectrum in addition to the seven hues he identified, Berlin and Kay (1969) speculated that Newton "saw" only seven separate homogenous colors dispersed on the screen by his prism because of linguistic limitations, rather than constraints in visual sensation. In other words, there were not enough color names to describe the various hues he observed. In fact the human eye can discern among several million colors of various hues, saturation and value. At the same time our basic color vocabulary is limited to relatively few words. All colors have three dimensions: *hue*, which is the attribute of the color by which it is distinguished from another color; *saturation*, which is the purity or intensity of a hue (sometimes it may be called chroma), and; *value*, which is synonymous with the lightness or darkness of the hue.

We are able to see colors because most surfaces have the capacity to absorb certain wavelengths of light, but some of the light energy that is not absorbed by a particular surface is reflected back to our eyes. This reflected light is interpreted in our brain as a certain hue. The interpretation depends on individual mood and association, as Rossotti (1983) pointed out:

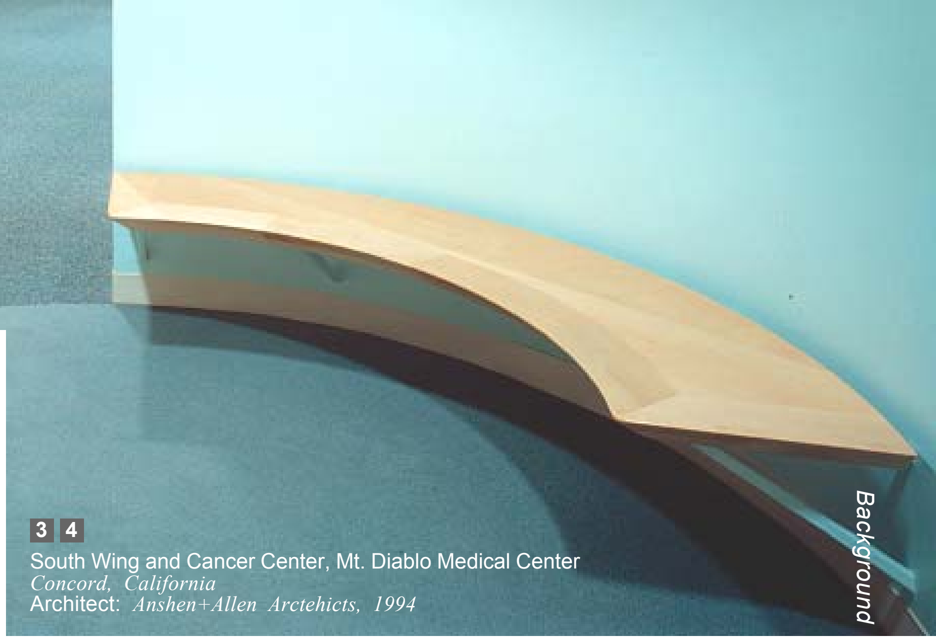
> …colour is a sensation, produced in the brain, by the light which enters the eye; and that while a sensation of a particular colour is usually triggered off by our eye receiving light of a particular composition, many other physiological and psychological factors also combine (p.16).

Thus the transmission of light is one aspect of color. The reception of the human eye and the interpretation of the brain is the other part of color vision. To summarize, the perception of color depends on the color makeup of the light, the surface material, and the health and age of the viewer's eyes.

Nassau (1998) noted that:

> The term 'color' describes at least three subtly different aspects of reality. First, it denotes a property of an object, as in *"green grass"*. Second, it refers to a characteristic of light rays, as in "grass efficiently reflects *green* light … while absorbing light of other colors more or less completely". And, third, it specifies a class of sensations, as in the brain's interpretation of the eye's detection of sunlight selectively reflected from grass results in the perception of *green*" (p. 3).

In actual practice, however, we rarely make the distinction among these uses, but understanding the effect of light on color is essential, particularly in regard to the spectral quality of artificial light. Three terms are essential to the discussion: (1) *Spectral Power Distribution* (SPD) is the amount of power from the light source in each color band or spectral region. This explains in part the difference between the light that comes from a standard cool-white fluorescent lamp, natural light, and the way it changes the colors of objects that reflect it. (2) *Color Rendering* is "an indication of how well colors are rendered under a given light source and depends on the lamps' spectral power distribution" (Steffy, 2002, p. 66). A system of measuring color was developed to describe the way colors are rendered by artificial light sources in comparison to daylight. The color-rendering index (CRI) indicates that



3 4
South Wing and Cancer Center, Mt. Diablo Medical Center
Concord, California
Architect: *Anshen+Allen Arctehicts, 1994*

high CRI lamps supply illumination of objects in a close to the measure of the whiteness of light produced by a given lamp. Color temperature is measured in Kelvin degrees. For example, a candle flame has a color temperature of about 2000K, incandescent lamp 2700K and white halogen lamps typically have a color temperature of 2900K (Steffy, 2002). The significance of these terms in the studies of biological effects of light is evident because light affords us the visualization and rendition of color. The subject deserves to be treated in greater depth, but that goes beyond the purpose of this monograph. More information about color vision can be found in *Human Color Vision* by Kaiser and Boynton (1996); and publications by Wandell (1995); Wyszecki and Stiles (1982); MacAdam (1970); and Le Grand (1957).

Because color vision takes place under relatively high brightness conditions, any discussion of color needs to simultaneously address light (Jones, 1972; Mahnke and Mahnke, 1987; Birren, 1988; Crone, 1999). “Color is not an inherent characteristic of surfaces. The color makeup of the light striking surfaces is as responsible for what color(s) healthy eyes see as the surface material itself” (Steffy, 2002, p. 15). Characteristics of color and light and the interaction between them may create color deception (after-image, simultaneous contrast), and/or color juxtaposition (harmony, quantity). These phenomena have been studied by Katz (1935), Albers (1963), Itten (1966), Kuppers (1973), Crone (1999) and others. Both after-image and simultaneous contrast are psycho-physiological phenomena that prove the fact that the human eye is not innocent; it is fallible when it comes to color perception.

Due to the symbiotic correlation between color and lighting, the two should be approached with equal attention to their psychological (Birren, 1961; Sharpe, 1974; Levy, 1984; Whitfield and Wiltshire, 1991), physiological (Asher 1961; Bernasconi, 1986; Fehrman and Fehrman, 2004; Kaiser and Boynton, 1996)), aesthetic (Agoston, 1979; Flynn and Piper, 1980; Nemcsics, 1993; Gage, 1999), and technical (Munsell, 1941; Albers, 1963; Committee on Vision, 1973) aspects.

“Although color researchers have not always been able to quantify the precise effects of various colors or light levels on humans, their research and experience seem to indicate that certain colors and light conditions often elicit typical repeatable reactions” (Woodson, Tillman, et al. 1992).

Color Scheme

Michael Eugene Chevreul, the nineteenth century French chemist who was the director of Gobelins tapestry works, is credited for establishing the color harmony principles, which are the basis of modern color aesthetic traditions. Originally developed for the arts, these color combinations are still governing the way many designers use color today. As part of their training designers study several color schemes (Chevreul, 1980), which can be broken into four broad categories: (1) Monochromatic color scheme, which uses shades and tints of only one color family; (2) Analogous color plans that are based on two or three adjacent hues on the color wheel such as a combination of yellows and reds; (3) Achromatic combinations, which are based on "neutral" colors such as white, beige, gray and black; and (4) Complementary color schemes, which are based on contrasting colors that are situated on opposite sides of the color wheel. Examples for such schemes are combinations of red and green or blue and orange.

Harmony principles can help in creating pleasing ambiance or intentional color effects, however what makes one combination of colors pleasing for one group of people may become an unattractive scheme for others. In addition, traditional harmonious combinations of colors were established at a particular time based on certain tastes, which eventually change over time. Thus, in addition to artistic talent, color designers should have practical experience and comprehensive understanding of the characteristics of colors as well as the nature of the human eye.

Critics of traditional color schemes have argued that while these color combinations can help designers create desired environments, they may also limit their creativity. Joseph Albers (1888-1976), for example challenged the tendency to follow traditional color harmonies, claiming that "What counts here—first and last—is not so-called knowledge, but vision—seeing" (Albers, 1963). Educated in the Bauhaus, Albers stressed the instability and relativity of perceived colors. He insisted that true understanding of color comes from intuition. Accordingly, many contemporary designers tend to ignore strict rules of harmony, and instead follow innovative choices and pleasing combinations based on other considerations.

"Albers wasn't the first to recognize that visual experience, not conscious choice, controls the perception of colors as harmonious, but he was the first to assert the primacy of the visual experience over intellectual considerations" (Holtzschue, 1995, p. 94). Another Bauhaus artist, Johannes Itten, observed how color combinations divide into blue-based and red-based colors, the same groups that are mistakenly termed warm or cool colors. Itten studied the natural need of the human eye to restore balance through complementary colors. He noted:

> Harmony implies balance, symmetry of force… If we gaze for some time at a green square and then close our eyes, we see, as an after-image, a red square… This experiment may be repeated with any color; and the after-image always turns out to be of the complementary color: The eye posits the complementary color; it seeks to restore equilibrium of itself (Quoted in Fehrman and Fehrman, 2004, p. 198).

Although color theory has roots back to ancient times with recorded doctrines (Gage, 1999), trends and fashions most often have influenced the application of color. In the world of fashion and consumer products, colors are changed constantly to increase sales of products. In order to survive in the marketplace, manufacturers of home furnishings, cars, and clothing coordinate their seasonal colors through organiza-

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Pediatrics & Infant Intensive Care Unit
Children's Hospital Regional Medical Center
Seattle, Washington
Architect: *Anshen+Allen Architects & Pacific Architects, 2000*

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tions such as the Color Marketing Group and the Color Association of the United States. These organizations allow designers and color consultants to dictate colors of products and literally force consumers to follow fashion trends regardless of their taste or preference.

While in the field of architecture and interior design the changes are slower, the same practice of color associations setting color trends is quite common. The explanation for this custom is to help designers adapt to the spirit of the time (Mahnke, 1996). These trends are influenced by climate, impressions and mannerisms of various cultural groups, as well as regional characteristics and styles. These and other considerations tend to have an effect on the ways colors are used in the built environment (Buhler, 1969; Aaronson, 1970; Birren, 1978). More about color schemes and color harmony may be found in the writings of Albers (1963); Birren (1982); Buckley (1975); Crone (1999); Fehrman and Fehrman (2004); Itten (1970, 1987); Jones (1972); Gerrisen (1974); Katz (1935); Kuppers (1973); and Munsell (1941), Pile (1997), and many other authors.

Color Order Systems

The Optical Society of America classifies a range of between 7.5 and 10 million hues, which the normal human eye can theoretically distinguish (Eco, 1985). At the same time, the *Dictionary of Color* (Maerz & Paul, 1953) lists just over 3000 English color names. Gage (1995) suggested that as a result of our inability to call so many colors by name, the modern color systems have resorted to numbers in order to distinguish perceptible differences of hues and values. Following the lead of James Clerk Maxwell in the 1860s, several scholars attempted to develop their own color order systems. Among the earliest systems is the one that was developed by Johann Wolfgang von Goethe (1749-1832), who studied color in an effort to refute Newton's discoveries about light as the source of color. Fehrman and Fehrman (2004) noted:

> Goethe was not concerned with the ultimate cause of color, only its effects on the eye and mind of the observer. Goethe explained color in terms of pairs. Yellow and blue are the two poles of whole system of color pairs, each of which has opposing qualities, plus-minus, warm-cool, active passive. Other pairs are red-green and orange-violet. Arranged in a circle, the six color of Goethe's spectrum express a system of harmony and contrast, depending on whether they are viewed from left or right sides of the circle. Blue harmonizes with its neighbors, green and violet, and contrasts with or complements its opposite, orange. This grouping of colors in pairs was crucial innovation, in comparison with conventional seven-color Newtonian wheel" (p. 260).

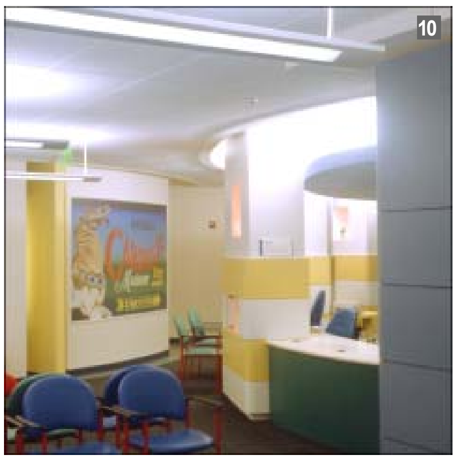
Goethe's contribution to the understanding of complementary colors was seminal to the same extent as his explorations of simultaneous contrast and afterimage. He understood that no pure color exists except in theory and explained the principal contrasts of color as polarity and gradation (Goethe, 1971). So, who was right, Newton or Goethe? The answer to this question is still not clear. The controversy over "science versus art" in color studies still exists, as Nassau (1998) observed:

> Rare is the scientist who is adequately familiar with Goethe's work on color perception (other than that he was vehemently opposed to Newton) or with the artistic uses of color. And equally rare is the artist who is acquainted with enough of Newton's insights into color and of the subtleties to which this has led modern science and technology (p. 25).

Sloane (1991), who compiled a useful collection of writings about color, noted that Max Planck the Nobel Prize-winning German physicist:

> [A]rgued that knowledge acquired through the reasoning of the physical sciences was pure knowledge and thus superior to, or significantly different from, knowledge acquired by other routes. The implication was that pure knowledge is revealed only to pure scientists and, as Goethe was not a scientist, his importance could be greatly diminished (p. 94).

The two most famous color systems are perhaps those developed by the American Albert H. Munsell (1858-1918) and the German chemist and philosopher Friedrich Wilhelm Ostwald (1853-1932). First developed at the end of the nineteenth century, the Munsell Color System is arguably the most widely used method for color specification in interior design. Munsell (1946, 1969) assigned each color a place on a ten-color wheel divided into five principal and five intermediary hues. The hues are designated by letter identification such as R, O, Y, G, B, V (red, orange, yellow, green, blue, violet). The second dimension of color, value, or the degree of lightness or darkness of a color in relation to a neutral scale, is depicted on the upright center axis of the scale designated by numbers of nine equal steps of grays ranging from dark at the bottom



9 11
10 12
Amb-Surge
Children’s Healthcare of Atlanta
Atlanta, Georgia
Architect: *Perkins & Will,* 2002

to light at the top. The third dimension of the scale, chroma, or saturation is indicated on the paths leading from the center of the scale to its perimeter. The steps of chroma are numbered up to 14, from low chroma to maximum chroma. The current Munsell color system, which went through several developments, includes more than 1,500 colors designated by glossy-finished chips that are marked with English names such as 5R 4/14, strong red; 5R 8/4, moderate pink, YG 7/4, yellow-green. The first letters indicate the hue, the second number the value rate, and the third number is the chroma.

The Ostwald system consists of a double- cone color system, in which the hues are located on the equator, which is divided into twenty-four different tonalities. The colors gradually intensify as they move from the gray center toward the perimeter of the equator circle, and gain a higher level of content as they move vertically toward the black or white poles. In his seminal book, The Color Primer, which significantly influenced artists of the Bauhaus movement, Ostwald (1969) noted:

> Experience teaches that certain combinations of different colors are pleasing, others displeasing or indifferent. The question arises, what determines the effect? The answer is: Those colors are pleasing among which some regular, i.e. orderly, relationship obtains. Groups of colors whose effect is pleasing, we call harmonious. So we can set up the postulate, Harmony = Order (quoted in Malnar and Vodvarka, 1993, p. 58).

Among the many other color systems one can mention The CIE (Commission Internationale de l’Eclairage); The DIN (Deutsches Institute fur Normung); The Gerritsen System; The Kuppers system; The Swedish NCS (Natural Color System); and Color Image Scale, developed by the Japanese color psychologist Shigenobu Kobayashi (1990, 1998).

In addition to color systems one can find a considerable volume of scientific studies which approach color from very different perspectives (Committee on Vision, 1973; Bernasconi, 1986; Nemcsics, 1993; Wyszecki, 2001) but these are beyond the scope of this manuscript.

HUMAN RESPONSE TO COLOR:
WHAT DOES THE RESEARCH TELL US?

Do Colors Possess Arousing or Calming Properties?

Striving to better understand the influence of color on human behavior, researchers looked at the physiological and psychological responses to colors. Building on these studies, various authors have claimed that specific colors have the capacity to arouse and excite people while other colors possess qualities that may calm or relax individuals (Kron, 1983; Digerness, 1982; U.S. Navy, 1975; Birren, 1982; 1959; 1950). The following section is a review of some of the studies regarding human responses to color properties.

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Radiation Therapy and Cancer Center
California Pacific Medical Center
San Francisco, California
Architect: *Anshen+Allen Architects, 1992*

Kurt Goldstein (1942) observed that patients with Parkinson's disease and other organic diseases of the central nervous system responded in a different way when they were exposed to green or red colors. Goldstein noticed that the red color had a tendency to worsen his patients' pathological condition and green seemed to improve it. He theorized that in the presence of a green color the abnormal behaviors became less prevalent, while in the presence of red these behaviors became more common. Based on his experiments and observations with a very small sample (3-5) of these brain-damaged individuals, Goldstein attempted to develop a theory that could be applied for all people. Several researchers, however, criticized the study noting that Goldstein's sample was too small, the color stimuli were inconsistently placed on pieces of colored paper, colored walls, or colored clothing, and the observations were never accompanied with any meaningful statistical analysis (Nakshian, 1964). Beach, Wise, and Wise (1988) noted that "Goldstein's theory was based on the notion that there existed a one to one mapping between color states and emotional states, which seems to be a gross oversimplification of the complex processes linking color and behavior" (p. 8).

Other researchers who tested the ability of colors to facilitate certain motor performances lend little evidence to Goldstein's theory. Nakshian (1964), for example, asked 48 subjects to perform nine tasks in three colored surroundings painted in red, green, and gray. He found that under the green condition compared to the red one, the performance of his subjects improved; but only in two of the nine assigned tasks. Similar results were mentioned by Goodfellow (1972), who studied the effects of color on psychomotor tasks. In another study published during the following year Goodfellow and Smith (1973) could not find evidence to the common notion that red weakens fine motor coordination whereas blue facilitates it.

The most common physiological gauges for measuring arousal are: (1) EEG, which measures the changes in the electrical activity of the brain (2) Galvanic Skin Response (GSR), which detects the changes in the skin conductance or resistance, and (3) AAR, which measures arousal through the changes in the alpha wave frequency in the human brain (Beach, Wise, and Wise, 1988). Over the years several studies used these gauges to detect arousal as a response to colors. Robert M. Gerard, for example, studied the effects of colored illuminated screens by measuring his subjects' blood pressure, palmary conductance, respiration rate, heart rate, eye blink frequency, and EEG (1958; 1959). He found a statistical difference between responses to red light and blue light. Eastman (1968) investigated how great contrast in colors could directly affect performance on visual tasks that involve color discrimination. Based on variations in illumination, he found differences in the performance of his subjects. Gerard (1958) contended that red light was more arousing than blue light on visual cortical activity and functions of the autonomic nervous system. He reported that as a result, red light produced more activity whereas blue light produced less activity among twenty-four males he tested. He found that red could lead to an increase in blood pressure, respiration, and frequency of eye blink, whereas blue had the opposite effect.

Based on his experiments, Gerard (1958) proposed the following general propositions:

1. The response to color is differential—that is, different colors arouse different feelings and emotions and activate the organism to a different degree.

2. The differential response to color is a response of the whole organism, involving correlated changes in autonomic functions, muscular tension, brain activity, and affective-ideational responses.

3. The differential response to color is lawful and predictable.

    a. It is related to specific characteristics of the stimulus, both physical (wave-length, intensity, number of quanta, and energy per quantum) and psychological (hue, saturation, and brightness).

    b. It transcends individual differences—that is, it is shared to a significant extent by members of the same culture.

    c. Individual differences in psycho-physiological reactivity to specific colors can be accounted for on the basis of previous learning experience, as reflected in color preferences and color associations, and characteristics of the organism, including personality variables such as manifest anxiety level (Fitch, 1999, pp. 141-142).

But Gerard himself cautioned his readers with regard to the generalizability of his findings. He mentioned the nature of his subjects (male college students), the fact that only three hues were investigated, and the restrictive conditions in which the results were obtained.

Ali (1972) tested Gerard's findings and also found more arousal in his subjects when they were exposed to red light compared to blue light. Ali's subjects viewed red or blue light for either 5 or 10 minutes. "From his findings, Ali concluded that higher level of arousal (cortical activity) takes place in red light which then requires a longer time period before resting alpha activity can resume" (Beach, Wise, and Wise, 1988:15). Jacobs and Hustmyer (1974) found red more arousing than green and green more arousing than blue or yellow. The researchers showed color slides (red, yellow, green and blue) for one minute each time to their subjects. They separated the color slides with white slides that were projected for one minute between each color. They observed a change in skin conductance (GSR) of their subjects that occurred within 15 seconds after the color slide was projected. Red yielded the highest change. Green, yellow and blue followed in this order. However they found no significant difference when they compared between the red vs. green condition and no notable difference when they compared the blue and the yellow conditions. They concluded that their GSR findings and their heart rate data support Gerard's (1958) results but their respiratory rate were contrary to Gerard's findings.

Jacob and Suess (1975) followed this study with an investigation about the effects of color on anxiety state. They showed subjects color slides for five minutes and administrated an anxiety test three times during the experiment. The researchers observed higher anxiety scores under the red and yellow conditions than in the green and blue situations. More recently, Mahnke (1996) reported on an informal experiment he conducted in 1994. He tested thirty-eight participants for psychological and physiological reactions to colored light, which they watched on a screen for two minutes. He claimed that most of his subjects associated red light with anxiety; blue and green with calming feelings of relief; orange with arousal but less arousing than red and more pleasantly stimulating; and violet with mystical feelings.

Findings from other studies have been rather ambiguous. Erwin, Lerner, Wilson, and Wilson (1961) presented subjects with four different color lights for five minutes. They noted that the duration of alpha wave onset was shorter for the green light. But they could not find a significant difference in the arousal of their subjects when they were presented with red, yellow, and blue conditions. The arousal was measured by suppression of alpha waves.

Wilson (1966) speculated that red induces higher levels of arousal than green. He showed highly saturated red and green slides to twenty subjects by alternating the slides every minute for a total of 10 minutes and concluded that there was a "support for the hypothesis that red is more arousing, more stimulating, more exciting!" (Beach, Wise, and Wise, 1988:16). Wexner (1954) hypothesized that certain colors are associated with particular moods. Accordingly, he claimed that red is perceived as "exciting" and "stimulating", while blue is considered as "secure" and "soothing." Mehrabian and Russell (1974) also theorized that color might affect people's mood and level of arousal, and that these differences in mood, arousal, and attitudes might affect task performance.

Nourse and Welch (1971) hypothesized that purple and blue would be more stimulating than green. They showed alternating green and violet light in an alternating pattern of one minute for each hue and for a total of six minutes. The researchers found that the GSR rates were higher when people were exposed to the violet light condition than the green light. However, they also found that the response to violet was much more significant for the people who were exposed to the green light first. Only fourteen subjects took part in this study, and the researchers admitted several inconsistencies in the presentations of the light configuration and other flaws in the mechanics of the research, yet "incredibly, this study is often cited as support for the differential arousal properties of color" (Beach, Wise, and Wise, 1988:17).

Research has been conducted on responses to colored lights, colored samples, and in fewer situations to colored rooms. Cheskin (1947) compared four rooms painted entirely in one color: red, blue, yellow, or green with furnishings in these same colors. He found that:

> In the red room an increase in blood pressure and pulse was noted. Subjects had difficulty working, or even remaining in the room for any length of time, due to over stimulation. The opposite effect occurred in the blue room—blood pressure and pulse declined, and activity slowed down. The bright yellow room produced no effect on blood pressure and pulse, however there were complaints of eyestrain, which made many activities impossible. No abnormal reactions were detected in the green room—with the exception that it produced monotony (Mahnke, 1996, pp. 40-41).

Scheurle (1971) recorded patients' blood pressure, pulse, rate of breathing, bodily sensations, and psychological reactions in rooms painted in different colors. In this experiment, the colors were applied to walls, ceilings, and floors using a transparent painting method. Curiously, patients' blood pressure was lowered when they entered the rooms regardless of the color, and then rose after they left the rooms. Mahnke (1996) explained the phenomenon claiming that the unusual surroundings that were introduced to the patients upon entering the rooms prompted concentrated attention to the environment. He reported:

> Upon entering the red room, four persons felt physically unwell mainly because they developed headaches. Two of those patients also started perspiring on the face, neck, and palms. Headaches were not developed in the blue room, with the exception of the two patients who had shown more extreme reactions in the red room; in the blue room they also felt unwell.
>
> Psychological reactions swung from sympathy and antipathy. One group of patients found the red room "beautiful," "light," "sunny," others found it too "glaring," "arousing," "exciting." Calmer emotions were generally noticed in the blue room; some patients found it "pleasant" "calming," "restful." Especially obvious were repeated remarks: "It's easier to concentrate, think, meditate." Other patients found the blue too "cool," "depressing," "sad."
>
> …the psychological reactions to a major hue vary between positive associations and impressions and negative ones" (Mahnke, 1996, p.41)

Evidently, these reactions are linked with studies regarding the effects of color on human emotions, in which researchers have asked whether a reliable mood-color association exists and whether color could change emotional response or moods. While several studies have demonstrated that color-mood association exists, it appears that different colors awaken different moods for various people. And although certain colors are more significantly linked with particular moods or emotions, there is no evidence to suggest a clear one-to-one correlation between given color and given emotion. “In spite of physical evidence to the contrary, most people continue to equate red tones with excitement and activity, and blue tones with passivity and tranquility” (Fehrman and Fehrman, 2004, p. 108). The authors claimed that in too many cases these are learned behaviors that people develop from early childhood in the context of their cultural heritage. The authors caution their readers to carefully distinguish between the culturally learned color associations and genuine physiological responses. The popular press promotes these unsubstantiated myths, and the design community contributes to the spread of these folklore tales by making indiscriminative statements about color that are unsupported by anything but biased personal beliefs. The authors concluded:

> Colors do not contain any inherent emotional triggers. Rather, it is more likely that our changing moods and emotions caused by our own physiological and psychological makeup at the moment interact with color to create preference and associations that we then link to the color-emotion response itself (p. 108).

The popularization of the notion that particular colors can set certain moods penetrated the design and architectural literature (Birren, 1982; 1973; 1959; 1950; 1988). For example, *The Human Factor Design Handbook* (Woodson, 1981) listed blue as a color that communicates “cool, comfort, protective, calming, although may be slightly depressing if other colors are dark; associated with bad taste” (p. 837). Before rushing to the application of these unsubstantiated recommendations, designers should refer to Walter Lippmann’ words: “To every human problem there is a solution that is simple, neat and wrong” (Quoted in Toulmin, 1990, p. 201).

Gebert (1977) studied four chambers painted in red, yellow, green and blue. Similar to Scherule’s conclusions, Gebert maintained that the red and the yellow chambers were stimulating, whereas the blue and green were more calming.

Kuller (1976) on the other hand argued that the issue of arousal and color is unresolved. He hypothesized that two separate mechanisms interact when people are exposed to different colors. He insisted that the intensity of a color would be more exciting for people regardless of the hue itself. He also assumed that different hues contain particular information for the human body. In a more recent study, Kuller (1985) found no evidence to support the claim that red interiors were more stressful than blue ones. He could not find significant differences among people who sat in a red room compared to a blue room.

Kuller (1976) also studied the effects of visual complexity and visual unity and found that the color and the visual patterning of interior spaces can have a significant effect on an electroencephalogram (EEG) and the pulse rate of people, as well as on their subjective emotional feelings. He noticed differences among men and women and their reactions to certain room colors. Men reported being more bored than women in rooms painted in a gray color. This so-called neutral environment was under-stimulating and was associated with restlessness, excessive emotional response, difficulty in concentration, and irritation. Similarly, over-stimulating environments with complex or incongruous visual patterns were shown to increase phasic arousal level (Berlyne and McDonnell, 1965). Strong colors and complex patterns demand visual attention, which were found to be fatiguing and distracting.

Mikellides (1990) also studied physiological arousal and found that the chromatic strength of the color was more significant than its hue in affecting people’s perception of which color is calming or exciting. During the late 1960s Acking and Kuller from the Department of Theoretical and Applied Aesthetics at the Lund Institute of Technology, Sweden conducted several studies on the effects of colors (1967; 1968a; 1968b; 1968c; 1969). Their findings indicate that various colors affect people’s blood pressure and the rate of respiration (Acking, and Kuller, 1972). They argued that “strong” colors in interiors give people a sense of excitement, while “weak” colors in the same environment give people the impression of calmness. Their studies focused on the indirect effects of color on people’s performance and moods. But like many other studies in this line of inquiry, they disregarded the cultural differences among various people, and the meanings that people assign to particular colors.

The effects of red and blue light were also studied in the context of gambling behavior (Stark, Saunders, and Wookey, 1982). Twenty-eight people were exposed to red or blue fluorescent ambient lighting while they were playing various card games. The researchers noted that the subjects in the red light condition placed more bets than those in the blue light condition. From these observations the researchers concluded that people under red light would display riskier behavior and that red light would stimulate gambling. Reviewing this study, Beach, Wise, and Wise (1988) offered another explanation for the increased wagers of the subjects and their greater betting frequency. They contended that "the red light was bothersome and subjects were trying to get away from the situation" (p. 19).

Color helps humans to interpret and understand the physical environment. Color perception involves aspects of visual, associative, symbolic, emotional, and physiological awareness. Mahnke (1996) divided the human experience of color into six basic interrelated levels. He illustrated his model with the "Color Experience Pyramid". Beginning at the base of the pyramid, the six levels are: "(1) inescapable biological reactions; (2) associations from the collective unconscious; (3) symbolisms of the conscious; (4) cultural influences and mannerisms; (5) influence of trends, fashions, and styles; and the highest level (6) the personal relationship the individual has to color" (p. 10). The model indicates that personal reaction to color is an interwoven experience that includes both psychological and physiological influences.

Similar explanations of the human response to color were provided by Marcella Graham in a document titled Health Facilities: Color Them Caring (U.S. Department of Commerce, 1976). As observances of skillful use and successful practical application of color in supportive environments, she summarized the categories as: (1) organismic or physiological: changes in blood pressure, pulse rate, autonomic nervous system, hormonal activity, rate of tissue oxidation and growth; (2) within the eye: changes in size of pupil, shape of lens, position of eyeball, chemical response of retinal nerve endings; (3) cognitive: memory and recall illusion and perceptive confusion, values judgment, associative response; (4) mood: stimulating, irritating, cheerful, relaxing, boring, exciting, melancholy, gay; (5) impressionistic: space seems larger, smaller, warmer, cooler, clean or dirty, bright or drab; people appear healthy or unhealthy, food is appetizing or not, older, younger, old, new; (6) associative: with nature, with technology, religious and cultural traditions, with art and science, typical or atypical.

The research literature contains many more studies regarding mood associations with color. These include the works of Crane & Levy (1962); Dearing (1996); Kugelmass and Douchine (1961); Meerum, Terwogt and Hoeksma (1995); Valdez and Mehrabian (1995); and, Dearing (1996). Subjective and objective impressions of colors research are included in the studies of Lovett-Doust and Schneider (1955); Loebach (1979); Hickman (1989); and Fleming, Holmes et al., (1990).

The review of the current body of knowledge about the human response to color illustrates some of the problems associated with these studies. Apparently some studies used non-representative samples, others included undefined stimulus variables, and some of the conclusions have been unsubstantiated by the findings. Despite these limitations, several authors have made attempts to interpret the findings for application in various designed environments (Birren, 1982; Cooper, 1994; 1995; Crewdson, 1953; Leibrock, 2000; Mahnke, 1996; and, Mousseau, 1984).

Mahnke (1996) rightly cautions us with regards to hasty interpretation of research findings:

> It would be erroneous to think that color design for interiors can or should be geared to a *specific physiological effect*—such as lowering the blood pressure of a person suffering from hypertension. Let me emphasize: *Specific physiological effects* (such as color healing) *should not be the designer's objective*. This would be a crude stimulus-reaction game—a risky game to play because it doesn't always take the psyche into consideration." (p. 42)

What are the lessons of the studies reviewed here? First, the answer to the question whether colors possess the properties to arouse or calm us is still indefinite, as Beach et al. (1988) noted: "It is evident that a great deal of inconsistency exists in the literature and findings are anything but definitive" (p. 21). The operational problems and the multifaceted nature of the response gauges that define arousal should make us doubt some of the findings and compel us to look carefully at the limitations of these studies.

Projecting slides of different colors with no apparent control for the brightness, for example, may contribute to arousal with no adequate way to equate the conditions under which the subjects experienced the color. Equating particular lights for their luminance does not help to compare them for their brightness (Neri et al., 1986). While some researchers pointed out how the stimuli in the experiments were matched for brightness (Stark et al., 1982; Nourse and Welch, 1971), others ignored the issue in their reports (Goldstein, 1942; Erwin et al., 1961). It is apparent that failure to control for brightness could be a significant factor in the ability to compare among the studies and the inconsistency of their results.

Another issue has to do with the various gauges that were used to measure arousal in the reported studies. The major indices (EEG and GSR) that were used in the investigations can be reported in various ways. Therefore, "when one tries to compare findings from one study to another, different types of responses might be reported under the same general response name, making such comparisons virtually impossible" (Beach, Wise, and Wise, 1988:23). In addition, the order of the presentation of each color to the subjects was not always reported. Some of the findings in the studies stress the significance of the order of the presentation of various colors condition. "This would lead one to believe that whatever differences might exist in arousal responses to color, they are of a short duration and transitory nature" (Beach, Wise, and Wise, 1988:24).

In some of the studies in which the stimuli took the form of painted walls and furniture the tendency was often to use highly saturated colors in the experiment. The application of these finding in real-life settings could be distorted by different illumination sources. In addition, the context of various building types may vary dramatically from the sterile laboratory conditions in which the particular colors were tested.

Too often the discussion about the arousal properties of color focuses on the properties of the color red. Humphrey (1976) hypothesized that the symbolic significance of red in nature comes from its ability to stand out from a background of green foliage and the blue sky. Red may indeed carry unique properties of arousal "because it is the color of blood" and "it is easily accessible by animals for the purpose of changing their coloration" (Beach, Wise, and Wise, 1988, p. 24). However, because of its loaded meanings, red may send ambiguous signals such as sexual insinuations, or in other circumstances threatening or aggressive behavior. Humphrey (1976) maintained that the response to red is a reflexive one. It is a cue for reaction that may change according to the situational context. But Beach, Wise, and Wise (1988) rightfully pointed out that "it is unlikely even in nature that such arousal lasts beyond a short duration, especially if presented within a context. Thus, claiming that certain wall colors will arous an individual, make one alert and thus more productive is certainly not warranted by the findings reported so far" (p. 25).

Kaiser (1984) argued that humans make certain associations to colors and these associations mediate physiological response. In other words, it is unlikely that we respond physiologically to color without the psychological associations carried with it. Fehrman and Fehrman (2004) reported on a study in which they investigated the effects of red, blue, and yellow on task performance and arousal in an attempt to determine the optimum color for educational, residential and commercial interiors. They used forty-two randomly selected male and female subjects who were placed in specially built environments colored in the three colors. The investigators controlled the saturation and the brightness of their pigments by using daylight illumination. The subjects performed various mathematical exercises, reading, and motor activity tasks while their galvanic skin response and pulse rate were monitored. To their surprise, the investigators found that under various pigment colors of equal saturation and brightness their subjects had comparable arousal and task performance scores. Furthermore, the results did not support the hypothesis that red is more arousing than blue.

Based on the findings in the reviewed studies, it appears that "arousal effects of color are neither strong, reliable, nor enduring enough to warrant their use as a rationalization for applying "high" or "low" arousing colors to create "high" or "low" activity spaces" (Beach, Wise, and Wise, 1988:25). A patient room in a healthcare facility will not become calming when it is painted blue, because human beings are not structured to simply be aroused or calmed down just because of the color of their surroundings.

Do Colors Have Advancing or Receding Properties? Do Colors Affect the Sense of Spaciousness?

One of the first dictums that design students learn in school is that "warm colors advance whereas cool colors recede". The physiological explanation for this phenomenon is that due to the properties of the human eye, the violet-blue images appear to be slightly farther away compared to the red light images, which appear slightly closer to the observer. The typical healthy eye receives the blue-green light (images) directly to the fovea, while the violet-blue light focuses slightly in front of the fovea.

> In an attempt to focus these images, the lens of the eye becomes slightly less convex and, therefore, the violet-blue image(s) appears to be slightly farther away. Red light (images) on the other hand, focuses slightly behind the fovea. Here the lens becomes slightly more convex and, therefore, the red images appear to be slightly closer to the observer (Steffy, 2002, p. 14).

The question is whether designers may use this phenomenon by specifying warm colors to advance surfaces towards the viewer and cool colors to recede them. It seems that such rules are rather naïve or one-dimensional given the complexity of the perception of color. The practice of specifying warm or cool colors to manipulate perceived size of settings appears as an overly simplistic act to remedy flaws in the design.

Kleeman (1981), for example, noted that blue may make a room look larger, and red may make it look smaller. He argued that the effect is increased when the saturation is stronger. Testing this hypothesis, Harmon painted a wall in a primary red at 50 percent reflectance and found that "an object placed against it appeared to be one-third larger at a six-meter distance from the viewer" (Kleeman, 1981:58). In another experiment, Harmon used a three-color wall with a band of white two feet down from the top of the wall, raw umber gray at 70 percent reflectance for seven and one-half feet, and below a thirty-inch band of primary blue at 55 percent reflectance. He found that:

> [A]t a distance of six meters from the viewer, the blue apparently moved five-sixths of a meter away from the viewer as measured with a retinascope. Pure black and pure white also apparently move in a similar fashion; black seems to move toward the viewer, while white seems to recede from the viewer (Kleeman, 1981, p. 58).

Payne (1964) provided an in depth review of the phenomenon that has been called the effects of color on "apparent distance". Studies regarding the issue can be traced to the early part of the 20th century (Luckiesh, 1918). Interestingly, not all the studies were compatible with the common notion about warm and cool colors (see Kleeman, 1981). Pillsbury and Schaefer (1937) for example exposed subjects to either red or blue neon or argon light through slits. They noticed that when the lights were placed at an equal distance from the viewers, the blue light appeared nearer. The results surprised the investigators because their results were in contradiction with the standard explanation for advancing and receding colors. Taylor and Sumner (1945) and Johns and Sumner (1948) introduced another aspect to the color-distance question. They found that when the color poles used for the experiment were kept in the same distance from the viewer, the brighter colors appeared farther away whereas the darker colors appeared at their actual distance. For the brighter colors the researchers used white, yellow, and green. Blue and black were used for the darker colors.

Reviewing this study, Beach, Wise, and Wise (1988) commented that the introduction of brightness into the color-distance matter explains why blue appears nearer than red. They noted:

> Viewing colors through squeezed eyelids is a favorite "trick of the trade" for color designers, who use it to gauge brightness differences independent of hues. Under this maneuver, one loses hue sensations while brightness contrast remain. It is essentially a reduction to scotopic vision. With this and the artificial pupils that shift vision out of the fovea in Luckiesh's (1918) experimental arrangement, the blue would appear brighter, and hence nearer, to his subjects. (p.68).

Tedford, Bergquist, and Flynn (1977) investigated the color effects on size in a controlled laboratory setting. They found that when they increased the saturation of a color slide it was more distinct when it was viewed against a gray background. Mount, Case, Sanderson, and Brenner (1956) studied the color distance effect in outdoor conditions and concluded that "no color variable has an inherent or unique position in space, and thus color can influence judgments of distance only in specific contexts involving primary and other secondary cues of relative position" (p. 213). Oyama and Nanri (1960) asked subjects to compare among combinations of various size circular forms in different colors. They too found that the size of the perceived figures increased as the brightness of the objects increased and the brightness of the background decreased. Their experiments emphasize the role of brightness as a dominant cue in the perceived size of objects regardless of the hue of figure or background.

Egusa (1983) confirmed the importance of brightness on the perceived size and also found that different hues influence the perceived depth of objects in the space. He also concluded that brightness and saturation effects outweigh the effects of hues in the perception of apparent size and distance. It is important to note here that the above experiments were mostly conducted in laboratory settings, which were very different from the contextual characteristics of ordinary interiors. In real, non-laboratory, built environments color is never seen in isolation. Therefore, one may speculate how colors affect apparent size of space when colors are manipulated in applied contexts.

Hanes (1960) also attempted to find correlation between color and spaciousness. He experimented with full-scale partitions that were mounted on a special movable device in a room shell of 12'L x 22'W x 8'H. The sidewalls and the back wall were painted in a medium gray, while the front wall consisted of replaceable partitions colored in seven different colors. The subjects in this experiment sat first in front of the standard gray wall and then were able to change their relative distance to the particular colored wall that was displayed in front of them until it appeared equal to the distance of the standard wall. The results demonstrated a very limited statistical difference. All colors except black appeared as advancing, with the brightest color panel (yellow) showing the largest effect (3.8"). The author attributed the results to the highly saturated hues and their contrast with the standard, gray wall.

In another experiment Pedersen and his colleagues (1978) asked subjects to rate the size of equal-size rooms that were painted in "cool", "natural", or "warm" colors. The authors could not find a significant difference in the ratings for the size of the rooms. Like in the other studies the observed effects were very small, and hardly seemed to be of importance. Other investigators who studied the effects of color on size include Ramkumar and Bennett (1979); and Baum and Davis (1976). These studies used small-scale models to test different effects of room size on crowding and other social aspects. Other researchers investigated the effects of color on size estimation with illuminated spaces. Aksugur (1977) tested "perceptual magnitude of the space" in model rooms illuminated in different color lights. Flynn and Spencer (1977) found very little effect of light color on the rated evaluative dimensions of rooms. Cool white fluorescent light was perceived as a light that contributes to a sense of spaciousness and clarity.

The sense of spaciousness may also be influenced by the common notion that colors have perceived weight. Mahnke (1996) claimed that high illumination, for example, enlarges appearance of volume and low illumination diminishes it. Accordingly, darker colors, he insisted, appear heavier, whereas lighter colors and less saturated colors appear lighter. Many interior designers use this strategy by painting high ceilings in small spaces in dark colors to make them appear lower or by applying "heavier" colors atop "lighter" colors to decrease the perceived height to width ratio of rooms.

Researchers who study the phenomenon of apparent weight of color include Payne (1961); Wright (1962); and Pinkerton and Humphrey (1974). Alexander and Shansky (1976) asked twenty subjects to estimate the weight of color by comparing square color chips to standard white squares.

The perceived weight appeared to be related to the level of saturation (chroma) as tested in the Munsell system and influenced by the value. Alexander and Shansky (1976) concluded "apparent weight is a decreasing function of value and an increasing function of chroma" (p. 74). Hue, on the other hand, seemed to be only a minimal determinant in the perception of weight. Only at the highest chroma the difference of the perceived weight of yellow and blue was found to be significant. To the surprise of the authors, yellow appeared heavier. Evidently, hue plays a very insignificant role in the perceived weight of colors.

Clearly, the apparent weight of color is a psychological characteristic that appears to be indisputable. However, the major effects of this quality might be attributable to the saturation and the brightness of the hue and not the hue itself.

So, what can we learn from the many studies about color effects on apparent distance and spaciousness? First, the rule that implies that warm colors advance planes towards the viewer and cool colors recede them is not substantiated in the findings of various studies. Second, "spatial impressions are most influenced by contrast effects, induced by saturation and, particularly, brightness differences between objects and background (Beach, Wise, and Wise, 1988, p. 79). Third, "spaciousness is enhanced by increasing lightness of the enclosing surfaces, and decreasing the contrast between elements that intrude into a space and their background" (p. 80).


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Doernbecher Children's Hospital
Oregon Health Sciences University
Portland, Oregon
Architect: *Anshen+Allen Architects & Zimmer Gunsul Frasca Partnership, 1998*

Do Colors Affect the Psychophysical Judgement of Time Passage?

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There is inconclusive research on how color influences the perception of time. Schlenoff (1972) studied the effects of color stimulation on time estimation. Clark (1975) conducted an experiment of two groups of salesmen. One group was assigned to a red room and other was assigned to a green room. Those in the red room thought that they were there twice as long as the time spent there. Those in the green room thought they were there less time than actually elapsed. Porter and Mikellides (1976) found contradictory results. After two identical lectures were given to two groups, those in the red theater found time had passed quickly; those in the blue theater thought more time had passed than had actually elapsed.

Smets (1969) investigated how people estimate amount of time spent under different light conditions. She found that her subjects estimated shorter time periods under red light condition than under the blue light. At the same time she noted that people perceived time duration as shorter for the first exposure of color light whether it was red or blue light.

Caldwell and Jones (1985) found no significant difference among their subject's time estimations under red, blue and white illumination. The researchers found no effect of red blue or white colored light on eye-blink frequency, skin conductance, finger pulse volume, heart rate or EEG measures. The investigators did observe some gender differences among their subjects. Males had a consistently higher skin conductance level and larger pulse volume than females. The order of the presentation of the colors had some effect too. But they found no significant effects on the alpha activity or peak EEG frequency under the different light conditions (Beach, Wise, and Wise, 1988). In conclusion, the effects of different colors on time estimation are limited and ambiguous.

Do Colors Affect Thermal Comfort?

Human experience leads to common associations between color and temperature. Most people continue to associate yellows, oranges and reds with the "warm" end of the color spectrum, and blues and greens with the "cool" side. This phenomenon is explained by the "basic" human experience of color as the black night, red blood, green grass and so on (Gage, 1995). As Wierzbicka (1990) proposed:

> Yellow is thought of as "warm", because it associated with the sun, whereas *red* is thought of as "warm" because it is associated with fire. It seems plausible, therefore, that although people do not necessarily think of the color of fire as red, nonetheless they do associate red color with fire. Similarly, they do not necessarily think of the color of the sun as yellow, and yet they do think of yellow, on some level of consciousness or subconsciousness, as of a "sunny color."

The problems with the habit to use color temperature sensations to describe colors has "often been a matter of puzzlement and debate" (Gage, 1995, p. 179). Arnheim (1974) asked:

> What is the common denominator? We are hardly reminded of a hot bath or summer heat when we perceive the dark red of a rose. Rather the color brings about reaction also provoked by heat stimulation, and the words "warm" and "cold" are used to describe colors simply because the expressive quality in question is strongest and biologically vital in the realm of temperature (p. 370).

Nevertheless, several researchers attempted to find whether certain colors communicate specific temperature connotations, and whether the use of particular colors can affect the thermal comfort of occupants. Itten (1961), for instance, experimented with different rooms that were painted either blue-green or red-orange. He found that individuals who spent time in the blue-green room felt cold at 59 degrees, whereas those who spent time in the red-orange room felt cold at 52 degrees. Clark (1975) experimented with employees of an air-conditioned factory and discovered that when the walls of the cafeteria in the factory were painted in light blue, employees felt cold at 75 degrees F. When the same walls were painted orange, employees were too hot at 75 degrees and the temperature had to be changed to 72 degrees to improve the comfort level of the subjects. Porter and Mikellides (1976) confirmed the results in a similar study.

Scheurle (1971) hypothesized that the body will always try to normalize a situation—sweating during heat and increasing metabolism during cold—and the feeling of warmth could be due to the organism's normal reaction. During conditions of excessive heat, the body's compensative reaction may be subjectively supported by the use of a cool color or warm color during the conditions of excessive cold.

While there seems to be an agreement with regards to the warmth of red-orange and labeling of blue, yellow-green, and white as cool colors, there appears to be more controversy over the question whether perceived temperature can be controlled through the application of particular colors. Houghton, Olson, and Suciu (1940) found no differences in oral and skin temperatures, pulse rate, or verbal comfort indications when they exposed subjects to illuminated screens painted in various colors. The subjects were kept in a room with constant temperature, while watching screens painted white, red, and blue. They pointed out that the effects of color on perceived temperature were minimal, and ranged within 1.5 degrees F.

Berry (1961) investigated whether people alter heat discomfort by changing color illumination. He found no effects of color on the comfort level of his subjects. Kearney (1966) studied the effects of temperature on color preference and discovered that his subjects felt uncomfortable under the hottest conditions (40 degrees C) when they were exposed to red light. At the same time their preference for blue color declined significantly when they were exposed to freezing temperatures. He found no effects of brightness on the comfort level of his subjects. It appears that blue and red are associated with cold and warm temperature states, but only in extreme conditions. Bennet and Rey (1972) provided subjects seated in an experimental chamber with blue, red, or clear goggles in their attempt to find an answer to the "hue-heat" hypothesis. The investigators could not find observable correlations between hues and thermal comfort judgments. Kleeman (1981) noted that "after reviewing the failure of this idea under widely varying conditions, Bennett and Rey concluded that the "hue-heat" hypothesis is widely held intellectually, but there are no hard data to back it up, including their own experiments" (p. 60).

In another study on the possible effect of color on the preferred ambient temperature, the researchers, Fanger, Breum, and Jerking (1977), recorded skin and rectal temperature of subjects who were exposed to extreme blue and red fluorescent lighting circumstance. The subjects were able to adjust the temperature up or down every 10 minutes to control their comfort level. Similar to the findings of other experiments, the subjects preferred a higher ambient temperature under blue light and lower temperature under red light. However, the effects were minimal (about .7 degrees F). The results led the authors to conclude that "the effect of colour on man's comfort is so small that it has hardly any practical significance" (quoted in Kleeman, 1981, p. 60). This study demonstrates the limitations of color in application for achieving thermal comfort.

The extreme conditions in some of the described studies were complimented by studies in which subjects were introduced to more realistic conditions. Greene and Bell (1980) surveyed students who were seated in triangular carrels in which the walls were painted red blue and white. In addition to asking the students to complete emotional response, personal comfort, and environmental quality scales, the students were asked to estimate the temperature of the settings. There were no significant differences in the perceived temperature due to the different colors. Pedersen, Johnson, and West (1978) were surprised to find little tangible results in their study, which introduced subjects to considerably different decorated rooms. The identical rooms were painted and decorated with warm hues (red, orange, yellow), neutral (white), or cool (blue and green) colors. The subjects were asked to complete several scales and estimate the dimensions as well as the temperature of the rooms. To the researchers' astonishment, the dimensional and the temperature estimates were almost not affected by the decoration or the color.

Rohles and Milliken (1981) suggested that the investigation in "real" environments produced different results with regards to the comfort levels of their subjects. They reported that people who were situated for an hour in an orange painted work stations in an open office setting felt more comfortable than in the ones painted blue. They also discovered that in a cooler than neutral setting, the subjects felt more comfortable when the walls were darker.

In conclusion of their discussion of the "hue-heat" hypothesis Beach, Wise, and Wise (1988) noted that:

> The spectrum of hue is not uniquely and unvaryingly attached to color connotations or sensations. Aside from contextually reproducible effects elicited by red-orange, blue and white, it appears that one cannot "micro-manage" thermal sensations or comfort by the simple introduction of surface or space colors, contrary to what some literature might imply (p. 59).

Thus, to the question whether color can affect the sense of temperature, or whether the use of particular colors can improve the thermal comfort of people, the answer might be only to a certain degree and within the context of overall design strategy. Certain hues can influence a person's thermal comfort level only on a psychological level, and this sensation usually is not accompanied by detectable physical reactions. In addition, the effect of temperature manipulation through color is minimal, and should not be applied indiscriminately by designers in their efforts to warm up or cool down a potential setting.

Do Colors Affect Other Senses?

In the tradition of the Gestalt psychology, Mahnke (1996) argued that color evokes associations with all the senses. It affects odor and taste, perceived weight and volume, tactile impression, sound, and temperature comfort. Examples of studies that attempted to determine color influences on persons' estimation of volume, weight, temperature, time, and noise include Chambers (1955); Schlenoff, (1972); Sundarapura (1989); Cartwright (1992); Grocoff (1999); and Sawada (1999). Birren (1982), for example, discussed research by Krakov, Allen, and Schwartz who argued that loud noise, strong odors, and highly-flavored tastes seem to make the eye more sensitive to green and less sensitive to red. In his efforts to explain the study, Mahnke (1996) claimed that warm colors might stimulate the senses, whereas cool colors might have a contradictory effect. Capitalizing on these assumed effects, Mahnke argued that the application of cool colors could compensate for noise problems in work environments such as noisy industries. He insisted that noisy environments, for example, would seem exaggerated if painted glaring yellows or reds. Therefore he recommended using specific colors, such as olive green to compensate for the noise; however, no substantial evidence or research findings were provided to support these recommendations.

Color researchers have studied the relations of color to the flavor of various foods. Pdgurski, (1995) for example, studied the relation between pastel colors and human appetite. As a general rule, people reject food if the color differs from what is expected; for example, meat dyed blue, green bread, or gray bananas are unacceptable to most people. The importance of the color of food is a known fact in the food industries. Consumers prefer orange juice when its color is intensified by artificial color. Wines have been judged sweeter when white or pink and less sweet when they appear more yellow or purple. Bakery products are associated with appetizing golden brown colors. Beverages such as coffee and beer are associated with certain colors. It appears that food color conditioning starts at an early age and evolves over years of experience and learned expectations. The ambience of environments in which food is consumed is also an important factor in the overall considerations of color-food association. Weight-loss plans, for instance suggest putting food on blue plates or illuminating the inside of refrigerators and dining area with blue light to suppress appetite. Polifroni (1993) studied the influence of dinnerware color on calorie and protein intakes of the elderly in a long-term healthcare facility. The investigator collected data on the food consumption of elderly people who had choices of three different color selections for dinnerware.

Illumination and background colors have been shown to affect the appearance of food (Sharpe, 1981; Helson and Lansford, 1970; Sanders, 1959). Newsome (1986) observed that in some cases, color can outweigh impressions created by food flavor. Clearly, color can easily be used to manipulate consumers in subtle ways because consumers react to colors in predictable ways that can be converted by advertisers to control and market products. These studies provide evidence on which color surrounding can be manipulated to enhance dining experiences. However, the focus of these efforts needs to disconnect the link between color and emotion, and instead focus on the way colors affect peoples' appreciation of objects and other people in the setting.

Color Preference and Color Meanings

The first recorded studies of color preference can be traced to Cohn, who conducted his research in 1894 (Eysenck, 1941). Since that initial effort, there have been numerous attempts to find correlations between emotions and colors. Sharpe (1981), Ball (1965), and Norman and Scott (1952) provided an extensive review of the early studies in this field. Classic studies of color preference such as Eysenck (1941), Guliford & Smith (1959), and Simon (1971) have suggested that most people find particular colors more desirable than others. Because much of the work in this vein indicates that individuals consistently choose certain hues over others, researchers assumed that characteristics of particular colors are associated with certain assigned meanings, which affect people's preferences. However, Arnheim (1974) suggested that:

> Quantitative studies on the color preferences of various populations have been numerous, partly because passing fashions are of interest to market researchers, partly because reactions to unanalyzed stimuli are easier for the experimenter to handle than studies requiring structural analysis … The results have been singularly unrewarding. Nothing of general validity emerged (p. 371).

Color preference is an ambiguous issue, in part because early studies on preference and color focused on the process employed to reach preference rather than on preference judgment itself. Early studies supported the hypothesis that there is a strong linkage between given colors and human preference. However, many of these associations are of an emotional character. Consequently, researchers have asked if certain colors could consistently induce specific emotions. "If so, is this a quality inherent in the color or innate within the organism which is released in the presence of a given color? Or is the linkage between color and emotion a purely cognitive one, which brings up a subsequent question of whether the mediated affect and color relationship is biological or learned" (Beach, et. al., 1988, pp. 27-28).

Studies of preference for colors that predated the 1950s often used one measurement: color was either pleasant or unpleasant. A color that was described as pleasant became synonymous with preferred color. The shift in preference research started with the study by Osgood, Suci and Tannenbaum (1957). Instead of looking at one-dimensional evaluation of pleasantness, the researchers rated colors on what they defined as Semantic Differentials (SD). This instrument allowed the researchers to measure the reactions of their subjects by rating on a scale defined by bipolar adjectives. Unlike earlier studies, Osgood and his colleagues studied a limited amount of colors in the context of objects such as a shirt, ice cream, rug, car, or cake mix. Each object was rated on twenty different scales. Yellow was rated as the most favorable color. Red and yellow were perceived as active colors, whereas green, violet, and blue were perceived as passive colors. Apparently, this led to the investigation of the suggested relationship between particular groups of colors and various moods such as "happy colors" "active colors" and so on. Possibly, this study became the driving force for the popularized branding of particular colors as causes of various moods.

Ever since color preference has been associated with personality, several psychologists such as Eysenck (1965), Jung (1968), and Birren (1967; 1978) studied the relationships between human personality and the reaction to stimulation. Birren (1978) discusses color preference and claims that extrovert personalities prefer warm colors while introvert people like cool colors. This notion, however, has been challenged in laboratory tests in Europe and the United Sates since the 1920s, and the results of psychological interpretation of color-temperature have been quite ambiguous.

Early studies of color preference lacked the scientific rigor that characterizes later research. These studies rarely controlled hues, values and chromas; the order of the presentations of the colors to the subjects was not evenhanded, nor was the illumination of the colors properly controlled. The focus of the research was mainly on the preference of hues. Red, blue and green were the preferred colors, whereas yellow and orange were considered less preferred.

Guilford's (1934) research made the first systematic attempt to study the contribution of hue, value, and saturation on the preference of colors. He found that when the value and the chroma were kept in the same rate, people preferred blue, green and red, and yellow and orange were less preferred. Eysenck (1941) collected responses from 21,060 subjects. He reported on preference for saturated colors in the following order: blue, red, green, violet, orange, and yellow. "His tentative conclusions were that preference for any color varies inversely with the luminosity factor of that color and that there appeared to be a direct relationship between liking for a given color and its differentiation from white" (Beach, et al., 1988, p. 31).

Guilford and Smith (1959) looked rigorously into the roles of hue, value and saturation in pleasantness ratings. They observed that colors that had added brightness were perceived as more pleasant. However, they warned their readers to be cautious with the application of their findings in real settings. Their study demonstrated the complexity of relationships among hue, value and chroma and supposed preferences to be dependent upon stimulus qualities.

Sharpe (1974) reported on color preferences linked to age among children and indicated that orange, followed by pink and red, were the favorite colors of children ages three to six. According to this study, sensitivity to color harmony is present at age four, although it does not become an element of artistic analysis until sometime between the ages of eight and twelve with full development occurring by adulthood. Girls between the ages of six and seventeen show a preference for warm colors whereas boys prefer cool colors. As age increases, hue is more important than saturation and brightness. Studying the association between colors and children's emotional life, Alschuler and Hattwick concluded:

> Red is the color of preference for preschool children who function naturally on an impulsive level; preference for red decreases and interest in cool colors increases as children move from the impulsive stage into the age where reasoning and greater emotional control are evident. The researchers found red to be associated with two extremes: feelings of affection and love or feelings of aggression and hate. As red is associated with strong emotion, blue is associated with drives toward control. They found that green was also used by children who function at a relatively controlled level, although they noted that "children who emphasize blue may give evidence of very strong underlying emotions which they have redirected and sublimated, whereas those who emphasize green often lack all evidences of a strong underlying core" (quoted in Sharpe, 1974, p.16).

One of the best-controlled studies about pleasantness of color combinations was conducted by Helston and Lansford (1970). Despite the small number of participants (10), the researchers were able to show that the pleasantness rating depended on the interaction between light source, background color and the color of the object shown to the participants. Background color was the most significant determinant of the preference judgment because of the contrast effect. While men were observed to prefer blue, violet and green hues, women found red, orange and yellow range most pleasant. Value contrast was identified as the most significant component for pleasant color harmony; the greater the lightness contrast, the more the color combination was preferred. The importance of this study is that it demonstrated for the first time the importance of other variables such as background color or illumination in the preference judgment of colors.

Bennett et al. (1985) showed that the size, shape, and the placement of a light source within a room influenced the rating of pleasantness. Their study showed that contrast played a central role in preference and the researchers indicated "that the perceived pleasantness of a color was changeable, and *not* an invariant quality within the color itself" (Beach, et al., 1988, p. 37). This study and many others may look as if color preference has been regarded in isolation from time and circumstances, but evidence demonstrates that this may not be the case. Walters, Apter and Svebak (1982) asked office workers to select the color they preferred every fifteen minutes. Over the course of five to forty hours the subjects chose different colors as time passed. The workers did not prefer one color across all the trials. These findings may have a significant impact on the efforts to identify the “correct” colors for a confined area such as a patient room in a hospital or a residential unit in a nursing home.

More recent studies about color preference include Radeloff (1991); Silver, McCulley, Chambliss and Charles (1988); Silver and Ferrante (1995); Ireland, Warren, and Herringer (1992). Whitfield (1984) studied people of different age, gender, and social status and found correlations between their background and their preference of wall color selections in residential environments. Kwallek (1996) studied characteristics of office settings. She found that white colored offices were rated by most people as the most spacious and most pleasant. Park and Guerin (2002) used an integrated color palette they developed to identify differences in color meaning and color preference of interior environments among people from four different cultures.

The reviewed studies suggest that despite the inconsistencies, saturation and value are crucial factors in preference evaluation. At the same time in the studies, which use evaluative scales of the Semantic Differentials kind, the context of a given object or circumstances can produce more accurate results. This is related to the issue of color meanings.

Rapoport (1982) argued that color is highly noticeable as a cue in the built environment. He notes, “the question of specificity or universality in color applies to its perception and naming as well as the meaning” (p. 111). Rapoport listed several examples of explicit color meanings. Among them “the complex color symbolism of medieval times based on the notion that every object has mystical meaning” (p. 113). Based on ancient religious rituals, the Old Testament, and the Greek and Roman mythology, colors were linked to nature. Accordingly, red which was linked with blood, symbolized power. Yellow was associated with warmth and fruitfulness because of the sun, and green symbolized youth and hopefulness as represented by spring. Rapoport (1982) stressed the context of the use of colors:

> There were clear and explicit rules for using colors: (a) only pure colors were to be used, (b) combinations of colors to give tints corresponded to compound meanings, and (c) the rule of opposites, that is reversing the “natural” meaning—thus green, which normally stood for youth and hope, could become despair (Blanch, 1972). Thus the use of color constituted an arbitrary system that needed knowledge of the cultural context to be read (pp. 113-114).

Color is a cultural matter, as Hutchings (1998) notes, “colors can have many ‘meanings’ even within one culture, hence each color must be studied within its context” (p. 207). However, researchers disagree on the linkage between culture and color preference, as Malkin (1992) points out:

> T. R. Garth conducted tests among children of six different cultural groups—white, black, American Indian, Filipino, Japanese, and Mexican—and found that preference differences were minimal among them; he concluded that the differences that do appear in adulthood are due to factors related in nurturing (p. 165).

Since color is used by various cultures for aesthetic purposes, for communication in the form of coding, for identification such as the delineation of ritual settings, and for symbolic intentions, the study of color needs to stay away from generalizations and stereotyping (Aaronson, 1970; Kaplan, 1975, Gage, 1995). Mihaly Csikszentmihalyi (1995) notes that objects in our homes may be without aesthetic value, but they are charged with meanings that convey a sense of integrity and purpose to the lives of owners. He addresses the myth that certain colors or shapes are universally pleasing and “belong” together:

> It is true that the light spectrum demonstrates regular relationships between abstract dimensions of color, such as hue, saturation, and brightness. It is also true that when we begin to think of color in this way we can generate categories of complementary or clashing colors. However, it does not follow that people perceive color according to the analytical rules developed by physical scientists.
>
> In his delightful investigations among illiterate Uzbeks in the Soviet Union, Luria found that village women refused to combine colored skeins of wool into meaningful categories because they thought each was uniquely different from the other. Instead of using abstract categories, such as “brown,” they said that a particular piece of wool was the color of calf or pig dung; the color of decayed teeth, or the color of cotton in bloom. On the other hand, men from the same village called or named everything “blue,” regardless of whether it was yellow or red” (p. 122).

Color is rarely an abstract dimension as Csikszentimihalyi points out. For the Uzbek women, association with dung and flowers organize and communicate colors in everyday life. We may deduct from this notion that in environments that serve a broad range of individuals, such as healthcare environments, some of the colors may have different meanings. While some people could associate green color with a comforting verdant hillside in springtime, others may associate the same color with a frightening moldy shower curtain. The same color may signal enchantment, suffering, or alienation.

Sivik (1975; 1974a) is credited for providing some of the most significant contributions to the field of color meanings. In his experiments he used the Swedish Natural Color system (NCS) as his color model. Unlike the Munsell color system, the NCS is based on color perception of six "natural" color sensations of red, yellow, green, blue, black, and white. The chromatic hues are arranged in a circle totaling 54 hues. In addition, for each hue there is a triangular chart that shows the pure hue and its relationships to white and black. A sample of Swedish adults were asked to judge seventy-one colors on 26 SD scales. From the factors analysis, Sivik chose four factors: excitement, evaluation, potency, and temperature. The findings did not exhibit any difference between hues with equal chroma on the excitement factor. This contradicted the preconceived idea that warm colors such as red and yellow were exciting while cool colors such as blue and green were calming. Sivik speculated that the reason that red and yellow were stereotyped as exciting colors is because of their brightness in comparison to the natural appearance of blue and green.

Sivik (1974a) discovered that blue was judged as more pleasant than any other hue. This was demonstrated across all the three parameters of the NCS: blackness, whiteness, and purity. The determinant for potency appeared to be in the degree of blackness, and the perceived color-temperature relationships were determined by the hue. Across all the three parameters, people judged yellow and yellow-red as warmest and blue and blue-green as the coldest colors. Sivik depicted his results on isosemantic maps, which showed the complex interaction process between the color properties and their associations.

The study of color meanings is complicated by problems of recognition of colors and the human ability to discriminate among them. "People mean different sensations by different color names" (Arnheim, 1974, p. 331). Sahlins (1976) argued that color is a cultural issue and that "every color discrimination is rooted in a sort of referential fallacy" as Umberto Eco (1985) explains:

> Psychologists frequently assume that classification of colours and utterance of colour names are linked to the representation of an actual experience; they assume that colour terms in the first instance denote the immanent properties of a sensation. Therefore, many tests are contaminated by this confusion between *meaning* and *reference*. When one utters a colour term one is not directly pointing to a state of the world (process of reference), but, on the contrary, one is connecting or correlating that term with a cultural unit or concept. The utterance of the term is determined, obviously, by a given sensation, but the transformation of the sensory stimuli into percept is in some way determined by the semiotic relationship between the linguistic expression and the meaning or content culturally correlated to it.
>
> Our problem, to quote Sahlins again, is "how then to reconcile these two undeniable yet opposed understandings: color distinctions are naturally based, albeit that natural distinctions are culturally constituted? The dilemma can only be solved by reading from cultural meaning of color to the empirical tests of discrimination, rather than the other way around (p. 160).

The problem of color discrimination is compounded by the limitation of language. Many languages of the world do not have a word meaning "color" (Lyons, 1995), and in many languages people are able to label only a minuscule fraction of the millions of color sensations, which people are capable to identify. It appears that the physiological mechanism of our sight enables us to distinguish millions of color-nuances, but the perceptual categories by which we identify and conceptualize colors depend on complex elements of culture and language.

Because the sensation of color is induced by the processing of the eye and the brain, as a result of the electromagnetic radiation that is reflected off objects and substances, people discriminate among colors in different ways. Even in the relative small number of hues that are specified in the Munsell set, people fail to discriminate among colors as Eco (1985) notes:

> The Farnsworth-Munsell test, which includes 100 hues, demonstrates that the average discrimination rate is highly unsatisfactory. Not only do the majority of subjects have no linguistic means with which to categorize these 100 hues, but approximately 68 percent of the population (excluding colour defectives) make a total error score between 20 and 100 on the first test, which involves rearranging these hues on a continuous gradation scale" (pp. 167-68).

The connection between color and language led linguists such as John Lyons (1995) to define color as follows:

> [Color] is the property of physical entities and substances that is describable in terms of hues, luminosity (or brightness) and saturation and that makes it possible for human beings to differentiate between otherwise perceptually identical entities and substances, and more especially between entities and substances that are perceptually identical in respect of size, shape and texture (p. 198).

The cumbersome form of the definition attempts to cover achromatic as well as chromatic colors. It includes the properties of shape, size and texture because together with color these properties describe the appearance of things. The definition makes explicit the fact "that the perception of color, and perception in general is species specific; that is to say, the way the world appears to members of one species, more particularly to human beings, is specific to that species" (Lyons, 1995, p.198). And finally, the definition emphasizes the prototypical aspect of color, which is demonstrated through the following example: "When we say that grass is green or that lemons are yellow, we do not mean that this is their colour in all instances and in all seasons: we mean that this is their colour prototypically or paradigmatically" (Layons, 1995, p. 199).

Studies of the vocabulary of color in various languages include the works of Clark and Clark, (1977); Conklin, (1955); Corbett and Morgan, (1988); Davidoff, (1991); and Wyler, (1992). Much of the research on color in natural languages over the recent decades has been inspired by Berlin and Kay's (1969): *Basic Color Terms: Their Universality and Evolution*. The Berlin-Kay hypothesis assumes that all natural languages have between two and eleven basic color terms. The hypothesis maintains:

> that there are eleven psychophysiologically definable focal points, or areas, within the continuum of colour and that there is a natural hierarchy among at least six of these focal areas determining their lexicalisation in any language; that all languages with only two basic colour-terms have words whose focal point is in the area of black and white (rather than, say, in yellow and purple); that all languages with only three basic colour-terms have words for black, white and red; that all languages with only four basic colour-terms have words for black, white, red and either green or yellow; that all languages with only five basic colour-terms have words for black, white, red, green and yellow; that all languages with only six basic colour-terms have words for black, white, red, green, yellow and blue; and that all languages with only seven basic colour-terms have words for black, white, red, green, yellow, blue and brown. As to the remaining four focal areas, purple, pink, orange, grey, there is no hierarchy among these: no one of them takes precedence over the others (Lyons, 1995, p. 209).

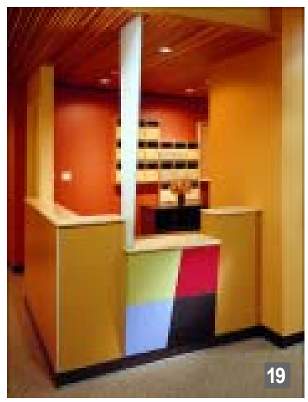
Berlin and Kay identified their eleven "basic" terms in nearly one hundred various languages. Their findings help to explain the relationship between biology and culture and lend support to the idea of color-universalism. Researchers who assign to this notion believe that individuals in *all* cultures have the same preferences for color, compared with the other group of scholars who maintain that culture is one of the significant underlying reasons that people of various cultures prefer different colors.

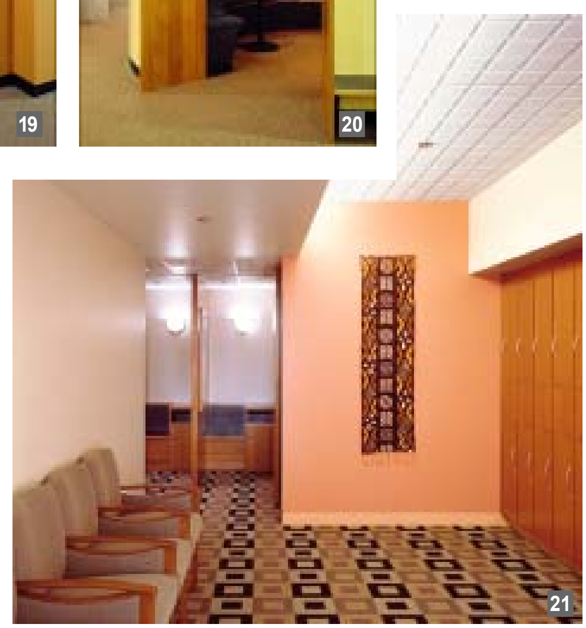
The authors of this manuscript believe that the instability of color-perception should caution the many scholars, as well as the so-called "color experts", who have been tempted to confidently articulate color meaning and preference across many cultures. The efforts to reduce the myriad of color-sensations to a simple and orderly scheme of minimal "basic" colors may help researchers who are looking to simplify the problem, but "they offer little comfort to those of us who are concerned to interpret the use of colour in concrete situations" (Gage, 1995, p. 187). The important questions in this context are "How do we define a culture?" "Which sector of a given society is in question? Which gender, which age group, which class, which profession?" (Gage, 1995, p. 191).

Examples of various perceptions of similar colors across different cultures are numerous. Yi-Fu Tuan (1974) noted that all people distinguish between black (darkness) and white (light). They carry "powerful symbolic reverberations" and have both positive and negative meanings. Black is associated with positive properties such wisdom, potential, germinal, maternal, earth-mother, as well as negative characteristics like evil, curse, defilement, death. White, on the other hand is associated with light, purity, spirituality, timelessness, divine, and at the same time with mourning and death. Brain (1979) pointed out that the psycho-biological significance of black is associated with excreta, decay, death or transitional state. Red is associated with blood, mother and child ties, war and hunting. And white color is linked with semen, mother's milk, and reproduction. Hutchings (1998) illustrated how the use of color and design varies significantly with culture through the example of traditional colors worn by brides in different cultures. In Western Europe and Japan it is white, in Eastern Europe it is red and black, in China red, and in African villages any color as long as it is bright.

Color preference, then, is a central part of the color studies literature. It appears that many of the assumptions that designers adopt almost for granted are based on misinterpretations of this line of inquiry. What can we learn from this section? The following conclusions are based on Beach et al. (1988):

- The assumption that there is a clear, universal preference for certain colors over others is simply not substantiated in the research literature.
- The supposition that colors have inherent qualities that can be transferred to the designed environment in order to induce specific moods is not supported by the research.
- Colors need to be studied in environmental context and not in isolation. Even in approximated settings, color studies have to be carefully controlled for hue, value and chroma. The hue component of colors seems to play a minor role in color preference and association.
- Although some evidence for a preferred hue exists – blue, the preference is not an *intrinsic* property of the color. Color preference is a function of factors such as value and chroma, illumination, background and surrounding conditions, possible color combinations, cultural factors, surface and textural effects, and many other variables.
- Preference of color is not a static state; it can change over time.
- Color is not an abstract dimension. Cultural background, the human ability to discriminate among colors, and the social function enclosed or the characters of the evaluated object influence color preferences. “Color perception itself is a highly complex process, and one should not expect the cognitive or associative components of color appreciation to be any less complicated” (p. 50).





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Ambulatory Care Center, Radiology Clinic
University of California San Francisco Medical Center
San Francisco, California
Architect: *Anshen+Allen Architects, 2000*

Colors Assessment in the Built Environment

The most important lesson that one can learn from the reviewed studies is that color needs to be studied in context. The findings of experiments that have been done in sterile laboratories are very limited because human beings process color information in the context of background, contrast effects, and the history of their own retina. Birren (1961) warned us:

> To seat human beings in cubbyholes or booths finished in different hues and attempt to measure their reactions would be both ludicrous and futile. Unless the test procedure compares favorably with the eventual condition under which color will be applied, and unless it may be agreeably undertaken, the human equation may destroy the scientific one" (p. 256).

Color is a powerful device in the built environment. It helps to distinguish between forms and their background and helps to identify objects beyond their form or size. Color is associative and symbolic and it is related to cultural experience and regional ways of life. But above all, color enriches our environment and adds beauty and excitement to the objects that surround us. The use of color in environments is an issue of human experiences rooted in value judgments and subjective statements of personal preference. The subject has attracted the attention of many philosophers of aesthetics who have raised significant questions over the centuries:

- Are aesthetic judgments capable of improvement and training, and therefore have some kind of objectivity?
- Does color communicate feelings, arouse feelings, purge or symbolize feelings?
- Why can different colors seem equally beautiful? Does the perception of beauty have connections with moral virtue, and with seeing something universal or essential? Does the importance of aesthetic practice associate with this?
- What is the role of the imagination in the appreciation of color?

In the *Critique of Judgment*, Immanuel Kant addressed the question of how judgments of beauty are possible, when they are incapable of proof. Kant's solution lies in the consciousness of the harmony of understanding and imagination. According to Kant, this harmony can be felt by any rational being and therefore "judgments of taste can be demanded by others…achieving the necessary objectivity" (Blackburn 1994, p. 8).

The environment that surrounds us influences our human psyche with aesthetic impressions. As part of our experience, we develop notions of what is beautiful and ugly. David Hume (1711-1776) used the key aesthetic term of "taste"—a faculty operating as an internal sense like sight or hearing. He suggested that taste is complex, subjective, and tenuous. The criticism of taste is an empiricist criticism; people disagree about color preferences and make judgments. A color cannot appeal to the ideas of taste directly, because everyone's taste is equal as far as its ability to produce ideas is concerned. If someone finds a color beautiful, that person cannot be convinced that the color should not be called beautiful; to be convinced would contradict the person's immediate experience that the color is beautiful. Hume's solution was to set up an empirical standard for those who have ideas. In other words, judge the qualifications of the judges. Qualifications are judged by their ability to exhibit regularity that other scientific judgments exhibit. Hume confirmed the empirical hypothesis that beauty could be located only in the experience of an observer (Townsend, 2001).

It is arguable whether color assessment can be or should be placed in the domain of logical knowledge because the assessment of color is primarily based on intuitive knowledge, obtained through imagination or images. By contrast, logical knowledge is obtained through the intellect of concepts. This is not to say that intuitive knowledge is unimportant. In ordinary life, constant appeal is made to intuitive knowledge and we cannot give definitions to certain truths—they are not demonstrable by syllogisms; they must be learned intuitively (Townsend, 2001).

Backing away from the fervor to find causal explanation that proves how certain colors cause certain behaviors, we may accept the fact that people have non-verbal intuitions in experiencing color and perhaps have "aesthetic experiences." The Swiss philosopher Edward Bullough believed that "this consciousness, as a mental state *sui generis*, is the level of psychic life which must be reached and maintained" (Townsend, 2001, p. 237). Bullough took this notion further, however, to explain phenomenal experiences. Phenomenal experience is "objective" when it concerns the phenomenon itself without uses or causes. Phenomenal experience is "subjective" when it is not concerned with the status of what is being experienced—which is what Bullough identifies as "aesthetic" (Townsend, 2001, p. 238).

The notion of an aesthetic experience or aesthetic emotion, is the essential quality of art and good design that is distinguished from all other objects and places in which one transcends the mundane to appreciating what Vitruvius refers to as "delight". What is this quality? Only one answer is possible—*significant form*, as Townsend (2001) teaches us:

> In each, lines and colors combined in a particular way, certain forms and relations of forms, stir our aesthetic emotions. These relations and combinations of lines and colors, these aesthetically moving forms, I call "Significant Form"; and "Significant Form" is the one quality common to all works of visual art (p. 260)…My term "significant form" included combinations of lines and colors. The distinction between form and color is an unreal one; you cannot conceive a colorless line or a colorless space; neither can you conceive a formless relation of colors (pp. 260-261).

Unfortunately the subject of philosophy of color is beyond the scope of this manuscript. Readers who are interested in this vast line of inquiry should explore among others the writings of Davis (2000), Hardin (1988; 1998), Hilbert (1987), Maund (1995), Westphal (1991), and Wittgenstein (1978).

In architecture, color is used to emphasize the character of a building to accentuate its form and material. In interior design, color is one of the central elements. The simple application of color has the power to enhance or devastate architectural volumes, emphasize objects in space and create tensions or calmness in interior space. "A well balanced color scheme can be one of the designer's most challenging tasks, involving knowledge in theory, physiology, and lighting. The use of color is always subjective, affected by personality, taste, and history" (Kurtich and Eakin, 1993, p. 249). Color must be an integral part of the total space, which includes the finishes, furnishings and accessories. It can communicate a concept, hierarchy, directionality and focus. Regardless of the professional background, the visualization of color in space can be a challenging task. Therefore, the ability to envision color in space can be best gained through experiment and experience.

Architects and interior designers differ in their use of color. While architects often tend to be conservative with the use of color, interior designers and decorators are more experimental. Fitch (1999) claimed that the differences between the professions may have historical origins. With the stylistic revolution in the first part of the 20th century, architects overthrew the dominant pseudo-historical styles, and discarded their coloration as well. "Purity of form was to be matched by purity of color," Fitch writes, "banishment of ornament was to be paralleled by banishment of pattern. As a consequence, much of today's architecture is almost without precedent in its monochromism, and even when color is employed, it tends to be either timid or inexpert" (p. 141).

Certain architects and painters have been well-known for their preference of colors. LeCorbusier, for example, advocated whiteness to suppress the "distracting din of colors" and to perform a "moral act: to love purity." The Dutch painter, Theo van Doesburg celebrated white as "the color of modern times, the color which dissipates a whole era." The Russian painter Kasimir Malevich who painted white squares on white backgrounds said that white is the ultimate color, the "true, real conception of infinity" (as quoted by Philip Ball, 2002). The American architect Richard Meier uses white almost exclusively in all his buildings, whereas Tadao Ando, of Japan prefers to leave his buildings in the gray color that stems from the natural concrete most of them are made of, while Ricardo

Legorreta of Mexico paints his buildings in bright amazing hues.

Hogg, Goodman, Porter, Mikellides, and Preddy (1979) investigated how architects and non-architects react to colors in interior spaces. The results showed no correlations between the judgments and the dimensions of hue, value and chroma. At the same time there were correlations between the architects and the non-architects. Each group showed a very different preference for the colors. The authors hypothesized that since architecture is a learned profession, and the appreciation for different colors is biased by the architectural education, the groups were at odds in terms of their selections. The hope is that better awareness of the differences between designers and laypeople will help professional designers address this issue in their interactions with clients.

Despite the many studies of color in the built environment, few of the findings could be realistically applied in real settings, as Kuller (1981) noted, "… a gap between research on one hand and practice on the other, the infamous application gap" (p. 238). Despite many decades of research, designers continue to be concerned with the application of color in the built environment. More conscientious designers make a great effort to conclusively state which colors are more appropriate than others, for specific settings. The writings of Faber Birren (1961, 1978, 1988), for instance, outline tangible benefits, and applicable guidelines for light and color in various settings such as offices, schools, healthcare facilities, psychiatric centers, industrial work environments, etc. However, his recommendations were mostly unsupported by research evidence.

Masao Inui (1969; 1967; 1966) conducted broad surveys on the actual colors used in various settings in Japan. The researchers used the Munsell color system to asses all kinds of interiors in Japan. They found that warm colors of high value and low chroma were used much more frequently than cool colors. Inui (1966) indicated that the color preference was significantly affected by the nature of the setting and the surface on which the color was applied. For example, the hues that were used in theater foyers were red, green and blue with much higher chroma than in reviewed living rooms. Hospital examining rooms and operating theaters often utilized green–yellow and green with high value and low chroma. The use of colors on ceilings and floors varied, but the important discovery was that the color pleasantness in these real settings was determined more by the social activities that took place in these interiors and much less by the psychophysical interactions between the color attributes and the users' responses.

Acking and Kuller (1976; 1972) used identical day rooms in a hospital that were painted in various colors. They used a green hue with fixed low and medium chroma and lightness, another green hue with medium lightness and high chroma, and a white hue with high lightness and low chroma. They could not find a preference for any of the rooms, but the subjects rated the white room lower although it was perceived as more open and least complex.

Sivik (1974b) was interested in color applied to objects. He studied the effects of color on two types of buildings: an apartment complex and a single-family house. Slide images of the environments were projected on a screen for the subjects. Sivik found three descriptors that matched the reactions of the people who were asked about the colors of the buildings: "emotional evaluation", "social evaluation", and "spatial factor". As for the colors, Sivik discovered that, contrary to the experiments with color chips, people liked the buildings that were painted in various shades of yellow-beige similar to natural wood, and disliked the buildings colored in violet or dark colors. In his attempt to validate the results, Sivik (1974b) interviewed 136 people on the street in front of three different apartment buildings and found that residents disliked the gray buildings and surprisingly approved of their own highly saturated blue building.

What can be inferred from these studies is, first that color is a complex topic that is influenced by lighting conditions, individual bias and the perceived suitability of the color to specific use. The second lesson is that people rate colors in real environments very differently from the way they rate colors in a laboratory test. And third, the meaning of the colored object is just as important as the color itself. Since colors carry their own meanings the question is to what degree one can find a match between the meaning of a color and the meaning of an object.

Two English investigators, Slatter and Whitefield (1977) hypothesized that certain colors were judged as more appropriate than others for a particular interior setting. They found differences between the choice of colors for an identical room that was labeled once as a bedroom and the second time as living room. In later studies they found that people tended to choose different colors based on the perceived style of domestic interiors.

Preference for colors in the landscape that surround human dwellings has been studied by Rachel Kaplan (1982), who observed that green is shorthand for nature, despite the fact that not all nature is green. "Greenness" would be equally attractive in the dead of winter when "white" would be a more accurate description (p. 186). With environmental preference questionnaires among a broad socioeconomic spectrum, Kaplan found a preference for nature scenes and natural settings whenever possible. Unlike Goethe, who addressed harmony and aesthetics of green as the symbol of both heaven and hope (1971: p.xi), Kaplan claimed that two characteristics are consistently present: (1) people seek natural environments even when they are distinctly unspectacular, and (2) natural environments are appreciated for their "thereness." The "green" aspect is important, but the people are not doing much in it or with it. What matters is the mere presence of the natural material" (p. 191).

Rise (1953) reviewed the state of the research on color in the classroom. He reported that both teachers and pupils appreciated freshly painted classrooms regardless of the painted schemes that were tested. He discovered that the effects of the painting were more social than any other color effect, a phenomenon known from other built environments. The newly painted walls communicated care and respect for occupants and practically no bearing on the psychological effects of the chosen hues for the experiment.

Schauss (1979) experimented with a pink color in jail holding cells. He claimed that pink can act as a natural tranquilizer and is able to reduce aggression among prison inmates. However, in a second study with better control, Pellegrini, Schuuss, and Miller (1981) tested the hypothesis and found no differences in attributes to the color pink itself. On the other hand the researchers observed that like the case of newly painted classrooms, the application of new color on the jail's wall sent a social message about care which was much more powerful than the pink hue itself or its biological effects.

Work environments were tested for productivity by Brill, Margulis, and Konar (1985; 1984) in their BOSTI study. The researchers asked 1000 office workers to pick color chips of the most preferred colors for workstations and rate the colors they had in their existing offices. They found that office personnel selected colors with low chroma for walls and partitions. The preferred colors were light blue, light aqua green and off-white. The results matched the existing facilities. The findings supported the notion that office workers prefer to work in predominantly "light" color environments. The preference of workers to work in lighter settings is also cited by Paznik (1986) who reported an increased productivity among Westinghouse workers.

Ainsworth (1990) discussed the impact of color on work performance and on conditions such as anxiety, depression, and arousal. Marberry (1994) reviewed the color trends from the 1950s to the 1990s in office designs. Summarizing the current knowledge regarding the use of color in workplace environments, Baughan-Young (2002) recommended the use of varied, multi-hued, warm colors in teaming or ideation areas because they facilitate brainstorming and sociability. She claimed that "a warm-colored environment will stimulate the autonomic nervous system of a person working in that environment briefly, but after a period of time, the activity of that person's nervous system will decrease to below normal level, leading to possible sluggish thinking and behavior." Other observations included in Baughan-Young's article maintained that "individuals placed in a chaotically colored room are silent and subdued; all white environments not only create glare but also under-stimulate the eyes; under-stimulation can result in eye fatigue just as over-stimulation can." Additional recommendations made the case that "Areas where individuals will concentrate should be decorated with a simple palette of cool colors. Subtle visual stimulation increases alertness." Like too many other guidelines by "experts" on the use of color in interior design, the research base for this information was not provided.

Attempts to review the status and adequacy of specification procedures in architectural color are collected in *The Influence of Color in Architectural Environments* (Flynn and Piper, 1980) and in *Light and Color: A Designer's Guide* (Spivack, 1984). The patterns and the taxonomies in these collections may be useful in facilitating an understanding or specification of design performance. In a search for empirical support, the *Effects Of Spatial Dimensions, Illuminance, and Color Temperature on Openness and Pleasantness* (Sawada, 1999) looked to quantify the effects of floor area and ceiling height, along with illuminance and color temperature. The use of a full-scale simulator, which is an experimental replication of a realistic setting, helps the results to be more readily applied in real settings. Mahnke (1996) provided a useful tool for color design in various environments. He advocated the use of the Polarity Profile—a semantic differential chart of descriptive adjectives that help to put into language the impressions to be created. On numerical scales of four degrees, one could determine the importance of impressions, colors, and special environmental problems.

Another example of the use of color in the built environment is in the universal signage system, as described by the International Organization for Standardization (ISO) and by the Occupational Safety and Health Act (OSHA) in the US (Benjamin Moore & Co. 2000: 7-30; 7-31). According to the OSHA law (April 28, 1971), all industries are required to mark physical hazards, safety equipment locations, and fire and other protective equipment with specific colors. The color code established by the American National Standards Institute (ANSI) and adopted by OSHA for use in hazardous areas should supplement other precautionary measures. Briefly:

- Red is used for protection equipment and apparatus, danger, and stopping (e.g., fire exit signs, fire alarm boxes, fire extinguishers and fire hose connections, stop buttons or electrical switches, etc.).
- Green is the basic color for designating safety and the location of first aid equipment, other than fire fighting equipment (e.g., safety bulletin boards, first aid kits, first aid dispensary, stretchers, safety deluge showers).
- Orange is the basic color for designating dangerous parts of machines or energized equipment, which cut, crush, or injure (e.g., safety starting buttons; exposed parts of pulleys, gears, rollers, cutting devices, power jaws; inside of movable guards, etc.)
- Yellow is the basic color for designating caution and for marking hazards such as striking against, stumbling, falling, tripping, and "caught-in-between." Solid yellow, yellow and black stripes or checkers attract attention to this environment (e.g., construction equipment; handrails, guardrails; where caution is needed; markings for protections, doorways, traveling conveyors, low beams and pipes, etc).
- Blue is the basic color to denote caution, limited to warning against starting machinery or equipment that is under repair.
- Purple on yellow signifies radiation hazards (e.g., rooms and areas outside or in-side buildings where radioactive materials are stored or which have been contaminated with radioactive materials; disposal cans for contaminated materials; burial grounds and storage areas for contaminated materials or equipment; containers for radioactive materials; contaminated equipment not placed in special storage.)
- Black, white or combination of black and white are the basic colors for designation of traffic and housekeeping markings. Solid white, solid black, single color striping, alternating stripes or checkers of white and black is used in accordance with local conditions (e.g., dead ends of aisles or passageways; location and width of aisles or passageways, stairways [risers, direction and border limit lines]; directional lines; location of refuse cans; drinking fountains and food dispensing equipment locations; clear floor areas around first aid, fire fighting, or other emergency equipment) (Benjamin Moore & Co., 2000: 7-30, 7-31).

There are, of course, several design guidelines for various built environments. Mahnke (1996) for instance discussed offices and video display terminals as well as computer workstations; healthcare facilities; mental health centers and psychiatric hospitals; industrial work environments; schools; and food services. In his extensive recommendations, Mahnke included interiors as well as exterior parts of buildings.

To conclude this short review of color in real environments, we note that to attempt to develop a theory on the foundation of isolated investigations in a laboratory setting would be useless. On the other hand, assessing colors in real settings is even more complicated because much of the environmental color meaning appears to be determined by cognitive processes, which are elements of the individual background that includes his or her education, experience, socio-cultural circumstances, and personal taste.

COLOR AND HEALTHCARE:
WHAT DOES THE RESEARCH TELL US?

Color and Health

Historically, medicine and healthcare were not seen as the only therapeutic domains. Art, philosophy, and religion were all perceived as healing disciplines. In today's world, the practice of medicine is based on empiricism through strict observation and experimentation. The change did not occur all at once, but when medicine gradually moved away from metaphysics toward science, the key to sound clinical judgments became unbiased observation, accurate measurement, and a straightforward plan of action. In new medical practice, only so-called hard data could be involved in making clinical decisions. Assumptions, opinions, and beliefs were not allowed to interfere with obtaining a clear picture of the body. Myths and speculations were supposed to be replaced by facts.

The literature regarding the healing characteristics of light and color both in science and the popular press is vast. The problem is that over the years it has become very difficult to separate among facts and myths in this line of inquiry. The history of medicine is saturated with ancient healing techniques and myths about the power of color in the healing process. In early cultures priests were also the healers because they were assumed to know the secrets of survival. The use of color for medications, amulets and other healing devices was common practice. For example, Egyptian healers prescribed colored minerals and parts of animals—red and yellow ochre, red clay, white oil, black lizards, indigo, green copper salt, raw red meat. Hippocrates, the founder of modern medicine, read the color of one's skin for diagnoses. In the first century A.D., Aurelius Cornelius Celsus prescribed medicines with color in mind. Writing on yellow: "Saffron ointment with iris-oil applied to the head, acts in procuring sleep, and in tranquilizing the mind" (Birren, 1978, p. 86). The Arabian Avicenna (980-1037) wrote about color and healing in the Middle Ages:

> Even imagination, emotional states and other agents cause the humors to move. Thus, if one were to gaze intently at something red, one would cause the sanguineous humor to move. This is why one must not let a person suffering from nose-bleeding see things of a brilliant red color (quoted in Birren, 1978, pp. 86-87).

The same healer noted that blue was expected to soothe the movement of humors. Flowers of different colors supposedly cured different diseases: red cured diseases of the blood, and white yellow flowers cured diseases of the "biliary system".

During the Middle Ages, mystics and alchemists talked of harmony with divine forces, God, philosophy, and natural laws. Making its way through Islam into Western Civilization, alchemy was concerned with the transmutation of metals and a blend of mystical and occult "science" with many references to color. The principal hues were black, white, gold, and red. Seven metals (related to seven planets), animals (eagles, salamanders, lions, crows, doves, swans, peacocks), and flowers were related to beauty and symbolism. The alchemist's greatest achievements would be "a true elixir of life, a red stone, potable gold, which could give everlasting life and freedom from disease" (Birren, 1978, pp. 87-88). But alchemy lost favor, and color therapy became obsolete when the medical science with its powerful diagnostic and healing tools came into existence. However there was a short intermission to this purely rational approach to medicine during the late part of the 19th century.

Edwin D. Babbitt, who was considered a charlatan, a genius, a self-proclaimed magnetist, and a psycho-physician, published in 1878 his 560-page manuscript *The Principles of Light and Color.* The book created a minor revolution in the art of color healing. Babbitt was interested in religion and spiritual truths and believed in the power of different colors to cure various illnesses. He argued that “Chromotherapy is based on eternal truth, and the sooner any great truth is adopted, the better it is for all concerned” (quoted in Birren, 1978, p. 89).

Babbitt sold color therapy books, “Chromo Disks” and “Chromo Flasks,” a “Thermolume” cabinet for color treatment, colored glass and filters, and a “Chromalume,” designed as a 57 x 21 inch stained-glass window “to be placed within a house facing south and behind which persons could indulge in salubrious color treatments” (Birren, 1978, p. 89). While people who believed in mysticisms revered Babbitt, the medical profession denounced him. The American Medical Association and the U.S. Post Office put fraudulent color healers out of business.

Although light and color are no longer used in the overarching way in which Babbitt proclaimed, light is recognized in contemporary medical practices. Niels R. Finsen of Denmark received the 1903 Nobel Prize for noting the properties of sunlight in treating tuberculosis. Sanitariums were then built with architectural features such as sun decks, sun parlors, and sunroofs. Even today light is still prescribed for treatment of psoriasis and infant jaundice and colored dyes still play a role in many medical procedures.

Still many of the early traditions with respect to color and healing are practiced today in several cultures. In Tibetan medicine, for instance, the color of bodily fluids, such as urine are utilized as diagnostic tools. The color of the skin, eyes and tongue also serves as an indicative tool for practitioners of Tibetan healing. Another ancient form of healing that is practiced up to our time is the reading of color of person’s aura. Some psychics claim that they can detect the aura, or the field of electrical activity, that surround a person’s body. These auras appear in a variety of colors, which have been associated with different emotional or physical states. The SQUID (Superconducting Quantum Interference Device) is a device used by researchers at New York University to measure electrical activity in the brain above the scalp. According to Fehrman and Fehrman (2004), activity of the brain can actually project out beyond the scalp signaling thoughts to the outside world. This electrical activity is believed to be what some people call auras.

There is no distinct division between the psychological, the somatic, and physical in the consideration for color therapy and healing. While color healing for physical illnesses has not received acceptance and credibility in modern medicine, the tolerance for what color can do for the human psyche is somewhat more evident. Several color healers believe that the health of the body and mind depend upon a balance of *aural* colors, and should a color be missing or out of balance, it can be compensated (Mahnke, 1996).

Semyon and Valentina Kirlian (1958) described a method of using high-voltage discharges to photograph “flare patterns” (Birren, 1978; Krippner and Rubin, 1974). Kirlian’s radiation-field photography captures auras demonstrating energy fields surrounding animate and inanimate objects. This photography with biofeedback techniques reveals emotional and physiological responses to color. Johannes Fisslinger (as described by Mahnke, 1996) provided a method of aura-photography of energy fields of the body visible in color. Birren (1978) commented:

> The very existence of the aura may help to explain, or at least to confirm psychic healing, in which certain rare persons can through ‘the laying on of hands’ offer relief in some conditions of human distress. There are some recognized researchers who believe that through Kirlian photography there is visible evidence of a flow of energy, or interaction, between human beings and their environments and that with psychic healers the corona of the healer may flow into the being of the person being treated. This may seem farfetched, but liberal psychosomatic medicine does not totally reject any such ’miracles.’ (p. 77).

Color healers believe in *chakra,* which is considered to be an energy center that keeps the body in balance. The energies of the chakras communicate with the autonomic nervous system and the regulation of hormone secretion—seven chakras from the top of our head through the torso of our bodies.

> Each major visible color has particular qualities linked to the chakras with which it resonates. An understanding of the chakras and the higher energetic links to the body physiology helps to explain why certain colors are used to heal specific illnesses (Malkin, 1992, p. 20).

Mahnke (1996) lists seven chakras representing seven colors. For example, vertex chakra (violet) stands for wisdom spiritual wisdom and spiritual energy. It influences the pituitary gland. Forehead chakra (indigo) stands for intuition (the third eye), and influences the pineal gland. Each color is also associated with specific diseases: Violet—nervous and mental disorders; indigo—disorders of the eye; blue—thyroid and laryngeal diseases; etc. Gerber (1988) explained: "There are intricate systems and approaches to color healing that are utilized by various practitioners" (p. 278). Color therapy is part of holistic medicine, which "addresses the balance between the body and mind and the multidimensional forces of the spirit. It regards humans as beings of energy and light, whose physical body is only one component of a large dynamic system" (Malkin, 1992, p. 41).

In his attempt to explain the differences between color healing and color therapy, Mahnke (1996) claimed that color can be therapeutic, but it does not mean sleeping in blue sheets to relieve backaches or drinking illuminated yellow water to relieve constipation. Mahnke confessed that in his early years as a color researcher he denounced color healing on the same basis that many do. As an example for his ambivalence toward color therapy he made a reference to a book by Christa Muths (1989), who listed nine methods of color healing for high blood pressure, low blood pressure, allergies, depression, cancer, and other ailments to restore proper balance:

> (1) Color intake through foods (2) Irradiation with the inherent color (3) Color intake through drinking (color irradiated water) (4) Bathing in colored water (5) Sunbathing in color (6) Irradiation with color (specific parts of the body) (7) Visualizing color (breathing exercises coupled with the visualization of color in sequence of the rainbow colors) (8) Breathing color (a visualized color is inhaled and exhaled) (9) Color meditation (quoted from Mahnke, 1996, pp. 35-36).

The use of color as a diagnostic tool in the healthcare environment has been explored since ancient times (Mishra, 1995). These tools commonly fall under "new-age medicine", "old traditions" with no substantiated scientific evidence. The guidelines for this "medicine" prescribe how to use color to bring harmony and balance within the psyche and the body through the use of color vibrations (Bonds, 2000), and chromotherapy (i.e., replacing color resulting from chromopathy, which is the lack of color). Chromotherapy includes heliotherapy (i.e., the treatment of disease by exposing the body to the sun's rays), solartherapy, and other color therapy treatments (Mishra, 1995). Color therapy suggests that colors are infused with healing energies. Rooted in Ayurveda, an ancient form of medicine practiced in India for thousands of years, the seven colors of the rainbow promote balance and healing in the mind and body. In Ayurveda, individuals have five basic elements of the universe: earth, water, air, fire, and ether (i.e., space)—and the proportions of each are unique to one's personality and constitution. When thrown out of balance through unhealthy living habits or outside forces, illness is the result. Ayurvedic medicine uses the energies of colors of the spectrum to restore this balance. Color therapy was also used in ancient Egypt and China. In traditional Chinese medicine each organ is associated with a color. In qigong, healing sounds are also associated with a color, which in turn corresponds to a specific organ and emotion (Dupler, http://www.findarticles.com/g2603/0000/2603000014/p1/article.jhtml).

Bernasconi (1986) noted that chromotherapy does not function with a practitioner and a passive patient, rather it searches beyond the dictates of physics and scholastic medicine outside the fields of metaphysics and parapsychology. It seeks an interdisciplinary point of contact for the effects of color to play out. It focuses on the forceful impact that color and light play on human lives.

While these kinds of therapies are questionable and require more investigation, Rike (1992), attempted to qualify the effects of therapeutic color application. The popularity and confirmation of the search for a literal cure in color is encouraged even further in such works by Roeder (1996), Cumming (2000), Ford-Martin (2001), Gimbel (2001), Liebermann, (1994), Baron-Cohen (1997), Bonds (2000) and Wills (2000) as well as numerous others.

Another use of color in healing is Feng Shui. This is an "ancient Chinese method of creating harmony and balance between the workings of universe and nature" (Fehrman and Fehrman, 2004, p. 251). It is also one of the fashionable ancient traditions, which was adopted by Western culture as a panacea for modern ailments. According to Feng Shui experts, particular colors in rooms or even whole buildings can enhance and improve individual's health and welfare. The use of certain color combination is based on the premise that all aspects of human lives are affected by macro as well as micro permutations. Consequently, the placement of a bed in a room or the choice of colors in a living room interact with weather patterns, political, geographic, and economic forces, and inevitably shape our lives.

Color is used also as a diagnostic tool or therapy method in the treatment of mental illnesses. Gimbel, for example, has studied mentally handicapped children and the use of naturopathy (being close to or benefiting from nature) since 1956. In his books Form, Sound, Color and Healing (Gimbel, 1991) and Healing Color (Gimbel, 2001), he offered information on color illumination and human sight in relation to health. He observed human reactions to colored illumination, and the relationship between the development of cancer and emotions. Gimbel argued that color aids in the restoration of mental stability.

Several tests involving color are used to determine normality and abnormality among psychiatric patients. A case in point is the Rorschach's inkblot test, which includes reactions to color. Rorschach's hypothesis was that color responses are measures of the affective, or emotional state. He argued that neurotics are subject to "color shock" (rejection) as manifested in a delayed reaction time when shown a color blot. He reported that red evoked shock responses in neurotics more often than did other colors; schizophrenics suffered color shock when they were presented with the color cards following the black and white cards. These assertive statements were criticized as Malkin (1992) noted:

> …Two major criticisms of it are the lack of work with normal subjects as a criterion against which pathological groups could be compared, and also the basic postulate that the way in which a person responds to color in inkblots reflects his or her typical mode of dealing with, or integrating, affect. In fact, researchers Cerbus and Nichols, in trying to replicate Rorschach's findings, found no correlation between color responsiveness and impulsivity, and no significant difference in use of color by neurotics, schizophrenics, and normals. Nevertheless, the weight of evidence still favors the Rorschach color-affect therapy (p. 294).

In her discussion of mental healthcare facilities, Malkin (1992) claimed that although some studies indicate that depressed people prefer dark colors of low saturation, and others claim they prefer bright, deeply saturated colors, individuals suffering from depression have a lack of interest in color. Malkin (1992) also reported on a study by Goldstein and Oakley (1986) in which they tested brain-damaged adults by requiring them to sort stimulus materials on the basis of form or color. They concluded that adults sometimes regress to a manner of information processing associated with an earlier developmental age.

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ER-7, Sinai Hospital of Baltimore
University of California San Francisco Medical Center
Baltimore, Maryland
Architect: *Anshen+Allen Architects, 1998*

Sharpe (1974) noted differences in responses to high and low saturated colors among schizophrenic adults with severe and mild autism. She reported that:

> …the presentation of high-saturated colors interferes with cognitive functioning for both groups more than does the presentation of low-saturated colors. Interference was greater for patients with severe autism than for those with mild autism, both of whom responded similarly to low-saturated [color] cards. There appears to be a direct relationship between the severity of the illness and the intensity of the response to the degree of saturation (p. 73).

24 25
Children's Play Area / Bob Costas Cancer Center
Cardinal Glennon Children's Hospital
St. Louis, Missouri
Interior Designer: *Directions in Design, 1998*

In another case Sharpe (1974) commented on the results of a study in Taiwan examining differences between schizophrenics and normal people. In color-usage tasks, schizophrenics used fewer colors, but more deep green and black, than the non-patient group, paralleling results conducted in the U.S.

In his account on schizophrenia and colors, Birren (1978) noted:

> Virtually no one ever singles out white as a *first* choice of heart. The color is bleak, emotionless, sterile. But white, gray, and black do figure largely in the responses of disturbed mortals. K. Warner Schaie, in discussing the pyramid tests in which wide assortments of colors are placed on black-and-white charts, noted that incidence of the use of white by schizophrenic patients was 76.6 percent as against 29.1 percent for supposedly normal persons! So anyone who places white first perhaps needs psychiatric attention. It would be better to dislike white, but here again few persons are encountered who so express themselves (p.125).

Frieling (1990) tested the hypotheses of Szondi who claimed that schizophrenics prefer yellow, manics prefer red, hysterics prefer green, and paranoids prefer brown—but he could not confirm the theory.

> Frieling's research showed cases suffering from episodic dimming of consciousness were marked just as often by their choice of yellow and white as those suffering from schizophrenia. And he found that although yellow does in fact play a role in pictures executed by schizophrenics, it is not all that dominant (Mahnke, 1996, p. 167).

Following the review of the studies in this controversial vein, we tend to agree with Brainard (1998) who noted that the majority of color therapy treatments have not been rigorously tested in mainstream modern medicine. Brainard concluded:

> That is not to say that there is no potential value in color therapy or no basis for what has been claimed about the healing power of color—it simply indicates that the level of scientific evidence is lacking. Hence, the views of scientists about such color therapies range from skeptical to scathing. In contrast, individuals with less stringent need of empirical proofs often embrace color therapy and are excited about its potential (pp. 267-268).

The critical question is whether patients do get better as a result of the specific therapeutic value of a particular treatment or because of other reasons, as Brainard (1998) rightly put it "Does color therapy work by way of a specific biological mechanism or are the patient improvements due to placebo responses?" (p. 269).

Color in Healthcare Environments

The research literature of studies about color use in healthcare environments is fragmented and inconclusive. However, there is considerable agreement among designers, providers of care and other practitioners that healthcare environments should be friendly, therapeutic, and promote healing to the greatest extent possible. Advocates of evidence-based decisions in the design process of healthcare facilities agree that designers need to consider several user groups—the patients, caregivers, visitors, and the community at large. Each group has its own needs, which can be grouped under functional needs and perceptual needs (Ruga, 1997).

One of the most cited studies in the research literature of healthcare settings is Roger Ulrich's study of hospital patients recovering from gall bladder surgery. Ulrich (1991) found that:

> Individuals had more favorable postoperative courses if windows in their rooms overlooked a small stand of trees rather than a brick building wall. Patients with the natural window view had shorter postoperative hospital stays, had far fewer negative evaluation comments in nurses' notes (e.g., 'patient is upset,' 'needs much encouragement'), and tended to have lower scores for minor post-surgical complications such as persistent headache or nausea. Further, the wall-view patients needed more doses of strong narcotic pain drugs, whereas the nature view patients more frequently received weak analgesics such as acetaminophen (cited in Ruga, 1997, p. 221).

The body of research regarding color in healthcare environments is minimal. In many of the reported studies the sample size is often small, and rarely is the research replicated to validate findings. To compensate for the lack of valid research, too often findings regarding physiological and psychological effects of color have been taken out of their laboratory context and applied indiscriminately to various healthcare environments. One notorious example is the belief that green is easy on the eyes and advantageous in medical environments. Fehrman and Fehrman (2004) observed:

> After spending hours in surgery visually focused on red blood, surgical staff would experience green flashes on the walls of the operating room, caused by the afterimage phenomenon. Hospitals replaced the white of operating room walls with light green to minimize these afterimages. It was then incorrectly inferred that a color used in hospitals as a visual aid must also beneficial in other environments. Based on the false assumption that green is restful, it was selected for use in redecorating the main cell block and solitary confinement area at Alcatraz Prison. From there it went on to coat the walls of libraries, classrooms, and public spaces. The indiscriminate use of green as a calming agent proliferated until the myth became established as a fact (p. 13).

Authors in the environmental design field have always been in search of a mechanism for translating theoretical developments in color research into clear and easy to use guidelines for practitioners. Accordingly, authors have used anecdotal knowledge to create guidelines for healthcare environments. Consider the following example from an informative book about special care environments for people who suffer from dementia:

> Yellow-based pinks, such as salmon, coral, peach, or a soft yellow-orange will provide residents with pleasing surroundings. The pale tints, soft apricot and peach, accent the skin's own natural pigmentation, and all of the colors, are the most flattering to human skin tones. Turquoise and aquamarine, considered "universal" colors, also compliment most people's skin tones. When people look better, they feel better! (Brawley, 1997, pp. 108-109).

Other examples include Chambers (1955) and O'Rear (1994). Marberry (1997) and Marberry and Zagon (1995) explored the direct impacts of color in healthcare settings. In *Innovations In Healthcare Design* Marberry (1995) provides a collection of papers authored by professionals concerned with the development of healthcare design. The articles address practical issues with practical guidelines following the active role set by the annual Symposia on Healthcare Design. Few of the articles discuss observations and experiences of use and integration of color in healthcare facilities.

Cynthia Leibrock (2000) offered case studies and research findings, demonstrating how attention to design details, including color, empowers patients in healthcare facilities and decreases their reliance on staff. The book provides findings from experiments, surveys, evaluation studies, and other forms of research in an attempt to explain how design details can reduce costs and improve the quality of care and living environments for patients in healthcare facilities.

Color finishes are examined in the *Flooring Choices For Healthcare Application* by Beattie and Guess (1996), and in *The Psychological Impact Of Surface Colors And Spectral Colors On Task Performance* by Stricklind-Campbell (1989). These studies investigate the psychological effects of color on subjects' responses to color variables for application to possible health guidelines.

Jain Malkin explored color preference tests in *The Design Of Medical And Dental Facilities* (1982). She postulated that there is a relationship between a person's color responses and their emotional state. These examples provide valuable summaries of integrating color knowledge into healthcare facilities. Malkin (1992) assembled research related to color specification for several healthcare settings as part of her extensive discussion of hospital interior architecture. Among the discussed settings are diagnostic imaging centers, children's hospitals, cancer centers, rehabilitation, critical care, chemical dependency recovery hospitals, birth centers, psychiatric facilities, ambulatory care, long-term care, and congregate care.

Reviewing the historical perspective of hospital design, *New Directions In Hospital And Healthcare Facility Design* by Miller and Swensson (1995) offered practical aid to architects and healthcare administrators. The book reviewed trends in healthcare facilities and fundamental changes, including paradigm shifts on the whole notion of health as a means of understanding the long-term future of healthcare design. The text did not separate color out as a specific issue, but rather addressed its importance and integration in the design of healthcare facilities. While the book provided numerous examples to illustrate the reviewed topic, the empirical evidence for several decisions and recommendations was absent.

Professionals active in the healthcare field, as well as in the study of environmental design, have published their observations within professional organizations such as the *Color Association of the United States; National Institute for General Psychology; National Institute for Research in the Behavioral Sciences;* trade publications such as *Interiors & Sources; Health Facilities Management; Health Affairs; Color Research & Application; Science America; Psychology Review;* and in professional journals such as the *Journal of Healthcare Design; Journal of Consulting Psychology; American Journal of Art Therapy; Journal of Clinical Psychology; Journal of General Psychology; Journal of Architectural & Planning Research; Journal of Healthcare Interior Design;* and *Journal of Experimental Psychology: General, Social & General Psychology Monographs*. Other publications with direct reference to the healthcare field include Lovett-Doust and Schneider (1955); Hurvich and Jameson (1957); Kugelmass and Douchine (1961); Crane and Levy (1962); MavNichol (1964); Burnahl (1982); Levy (1984); Torrice (1989); Mikellides (1990); Whitfield and Wiltshire (1991); Kawamoto and Toshiichi (1993); Cooper (1994); Meerum, Terwogt and Hoeksma (1995); Valdez and Mehrabian (1995); and Foreman (1999).

Patient color-preference in hospital environments was explored by Schuschke & Christiansen (1994). Warner (1999) discussed color preference of residents with symptoms of dementia or Alzheimer's disease. Beck & Meyer (1982) studied design for working, waiting, healing and living environments. The authors reviewed design attributes from the user's perspective within the healthcare environment. Carpman, Grant & Simmon (1986) also looked specifically at hospital design and the end-user position. Active participants in healthcare design have offered their own personal and collected observances with guidelines for long-term care design (Cooper, 1994; Flynn & Piper, 1980) hospital design (James & Tatton-Brown, 1986; Miller & Swensson, 1995), pediatric design (Pence, 2000), and general healthcare environments in general (Leibrock, 2000; Malkin, 1990, 1992;

Flynn & Piper, 1980; Marberry, 1997; Woodson, Tillman et al., 1992).

The controversy over the use of white color in healthcare environments is an appealing example. Malkin (1992) argued:

> Evidence suggests that bland, monotonous environments cause sensory deprivation and are detrimental to healing. The brain needs constant change and stimulation in order to maintain homeostatis (stabilization of physiological functions). In addition, white walls cause considerable glare, which in turn causes the pupil to constrict. White walls have a clinical appearance that is unfamiliar and strange to most people; the absence of color is eerie. The combination of white walls, white ceiling, and white floor create strange perceptual conditions that can be very upsetting to patients trying to stabilize their balance or orient themselves (p. 56).

The use of green color in healthcare environments was mentioned before, however, many color consultants have made their case against the use of green in these settings because they appear "institutional". For instance Mahnke (1996) noted:

> Those who found the "hospital green" of the past unpleasant because of its institutional associations can place white in the same category. Psychologists now are in general agreement that institutions should look anything but institutional (pp. 80-81).

The issue of wayfinding with the use of color is another topic, which has been explored by researchers of healthcare environments. Hospitals are notorious for being labyrinths. Hospital environments became difficult to negotiate because of their complexity and enormous scale, changes in technology and provision of healthcare, and history of awkward renovations. Garling (1984) and Weisman (1981) indicated that the major elements in wayfinding include degree of differentiation, visual access, signs, and architectural legibility. Stephen and Rachel Kaplan (1982) taught us that humans are processors of information who perceive, build mental maps, care, and rationalize. People experience environments through preferences and non-preferences and develop coping strategies such as choice, control, interpretation, and participation. Distinct colors, they argued, can be used for landmarks, graphics, signage, and other visual cues to reinforce wayfinding. However, Park and Mason (1982) have demonstrated that most people do not find color coding as effective in wayfinding as a form symbol. Evans, Fellows, et al. (1980) found that a distinguishing color on accent walls could be useful in a monochromatic environment. Goldstein and Oakley (1986), claimed that color is a more useful aid than form for individuals with head-injuries impaired in discrimination learning and memory retention. Malkin, (1992) echoed these findings, claiming that for special populations such as elderly and persons with dementia, color-dominance is preferred over form-dominance. Wayfinding and place recognition through color as a specific aid tool has also been discussed by Cooper (1994) and Leibrock (2000).

As a result of the natural process of aging, human vision is impaired and several processes associated with it slow down. Adaptation in moving from brightly illuminated to darker areas slows as well as the accommodation, which is the process of focusing on an object or task. Two other age-related processes are Presbyopia, which is the inability of the eye to focus on near objects or tasks, and the yellowing combined with the clouding of the lens. As the two phenomena develop, images become more blurred, the eye becomes more sensitive to glare, and more light is required to conduct daily activities.

Steffy (2002) notes:

> Some color vision deficiency does occur with age. As the lens clouds, there is less ability to distinguish color at lower light intensities and/or distinguish between dark colors. Generally, all colors are dulled, but blue is particularly muddied (p. 14).

Many authors of publications intended for designers discuss the natural hardening and thickening of the lens with old-age and the yellowing of the lenses that occurs with the aging process. Authors argued that as a result of the reduced amount of light the human eye perceives, color distortion may occur with aging. The eye, they asserted, also has more difficulty in accommodating to variations in distance, adapting to light variation, and handling glare. Older adults may require some 4 to 5 ½ times more illumination to distinguish a figure from the background (Cooper, 1993; Hiatt, 1991; Hughes and Neer, 1981; Liebrock, 2000; Pastalan, 1977).

Christenson (1990) for example pointed out that:

> Gradual yellowing [of the lens] impairs the perception of certain colors, particularly greens, blues, and purples. Dark shades of navy, brown, and black are probably not distinguishable except under the most intense lighting conditions. Furthermore, differences between pastel colors such as blues, beiges, yellows and pinks are often impossible to detect (p. 11).

In her informative book, Leibrock (2000) noted:

- Yellow color schemes may cause difficulties for people who have yellowing lenses. Bright yellow colors can intensify to the point of annoying. Pastel yellows are difficult to distinguish from white (which appears yellow).
- With yellowed lenses, blue, blue-green or violet color schemes may appear gray, especially in daylight or fluorescent light (in a blue color spectrum). Blue tones can be distinguished from other colors more easily at night when lighted by tungsten light (standard light-bulbs).
- Yellow tinting of the human lens has little effect on red tones. However, people with color-blindness have difficulty distinguishing between green and red (p. 82).

Brawley (1997) reported on the extent of vision problems. Men are more affected than women by differing degrees of color blindness; more than 10 million Americans have significant vision problems; over 3 million have partial sight. Most have deficits in color perception that accompany eye diseases and reduce the effectiveness of certain color combinations. With congenital color deficiencies and acquired eye diseases, there are some 35 million people in the U.S. with reduced abilities to distinguish colors (Arditi, 1995). As a result, Brawley (1997), like many other authors of publications about environments for older adults, makes a strong case for enhancing visual function with high contrast.

Cooper, Ward, Gowland, and McIntosh (1991) studied color vision among well-elderly. They confirmed that elderly lose their abilities to discriminate among unsaturated colors. This was more pronounced for cool hues and more noticeable after age 60. Elders are best able to discriminate among highly saturated colors at the warm end of the spectrum and they are less able to see pastel blues on the cool side. Blue/purple was the most difficult color to see.

However, it is interesting to note that in another study, researchers found very little change in color vision among 577 males ranging in age from 20 to 95 (Gittings, Fozard, Shock, 1987). This longitudinal study that lasted for 10 years, found that color vision "accuracy remained above 90% for all but men in their 80s at the beginning of the observation period. Cross-sectional age differences for women volunteers in the Baltimore Longitudinal Study of Aging were similar" (Fozard, 1990, p. 152). These findings are particularly important, because the notion that visual capacities decline in old age has been a long-standing theory, which is challenged by this study.

Judith Mousseau (1984) investigated whether there was any consistency among designers regarding the criteria used for selecting and specifying color in housing for the elderly. Data were gathered by means of a questionnaire and personal interviews with designers responsible for the design of housing for the elderly. The findings indicated that there was an awareness of problems encountered by older people as a result of the aging process, such as the changes in color perception. However, it appeared that many of the designers interviewed utilize design elements other than color to provide a safe environment for the elderly.

Seeking to determine if color is useful in changing undesired behavior among institutionalized elderly, Malkin (1992) describes the research conducted by Cooper, Mohide, and Gilbert (1990):

> Doors leading into restricted areas and out of the ward were painted to match the adjacent wall; interiors of restricted areas were painted in pale colors to avoid attention; closet doors in bedrooms (formerly accent colors) were painted the same color as adjacent walls; bedroom doors and frames were painted in bright primary and secondary colors, with colors repeating as infrequently as possible; bathroom doors were accented with strong colors; walls behind toilets and sinks were painted the same color as bathroom doors; the door and adjacent walls leading into the activity area (also used for dining) were painted raspberry red; the interior of the activity area was painted a cream color on one wall, Kelly green on another, and coral on a third.
>
> The experiment showed that each type of undesired behavior (with the exception of patients wandering into others' bedrooms) decreased; no change was noted in desired behaviors, except for longer stays in the activity area. Patients appear to be attracted to strong color cues (as evidenced by increased wandering into other bedrooms); however, when cueing was coupled with coding, such as in the identification of the sunroom, patients seemed too disoriented to distinguish between colors or to associate specific colors with particular meanings. Staff noted that the less cognitively impaired patients began to locate rest rooms more frequently after the color intervention. The authors of the study conclude that cueing out (minimizing attention by eliminating color cues) is an effective way of reducing undesired behavior, and that color coding is an ineffective means of helping elderly patients function. They suggest that color coding may be more effective when combined with other sensory cues, such as an accent color door combined with a

> photograph of the resident (Malkin, 1992, pp. 391-392)

Maggie Calkins (1988) explained that color can be used with individuals with dementia for a system of location cues—but eventually they will lose this ability to recognize colors. She noted:

> Some people with dementia retain the ability to recognize and attach importance to colors long into the course of the disease. Colors should be clear and bright. In a study by Alverann (1979) a group of elderly residents preferred warmer colors (reds, yellows, oranges, browns) over cooler shades (blues and greens).
>
> …Once a color scheme has been chosen, it can serve as the basis for a system of location cues for residents. For some, a wristband color-coded to match their room will provide a needed reminder. Also, brightly contrasting colors on the door, door frame, or room identification sign, or a bold accent stripe inside the room, can help a resident find the way to the correct quarters.
>
> Evidence suggests that most Alzheimer's and related dementia victims will eventually lose the ability to recognize colors. Therefore, it is suggested that colors be used only in conjunction with other types of cues (p. 50).

David Hoglund and Stefani D. Ledewitz (1999), who designed several Special Care Units for people with dementia suggested that color coding, conventional signage, and differentiation of finishes, flooring, hardware, and lighting do not provide perceptible cues for most people with dementia. Older adults cannot distinguish slight changes in color, and color-coding is too complex for most residents to understand. Accordingly, they believe that landmarks and sight lines hold the most hope for environmental wayfinding and cueing. They speculated that most environmental cueing is too subtle for people with dementia. People who suffer from this disease have difficulties to associate colored forms with particular meanings such as their room.

Calkins (1988) who also studied the needs of people with dementia recommended a user-oriented approach to color specification. Based on Roach (1985) she argued that residents with dementia should participate in the decision making process:

> It is helpful to have the residents decide which color(s) they like best and want in their surroundings. Those who do understand direct questions about color preferences can be given a variety of colored items (crayons, markers, paint chips, colored paper), then observed to see which ones they use most often (Calkins, 1988, p. 64).

However Mahnke (1996) criticized this approach in a different context. He maintained that a favorite color does not mean one wants to be surrounded by it. He noted: "There is a difference between favoring a particular tone when shown color chips and living with it on all four walls" (p. 165).

Malkin (1992) reviewed a series of color research publications and pointed out to some of the controversies regarding the influence of color in healthcare environments:

> Margaret Williams (1988) a nurse researcher explains, "Color…has aesthetic and symbolic meaning…however there is no evidence that certain hues actually affect health; studies of patient behavior under different color conditions are lacking".
>
> Will Beck (1983), physician and prominent researcher in lighting, suggests that "there is very little hard evidence that visual responses to colored light evoke specific physiologic responses. The data suggesting a color response on blood pressure, heart rate, and respiration, are, in my opinion, inconclusive. My own studies have been completely equivocal. We do realize that there are emotional responses to certain colors, so we should let these guide us rather than anticipate a therapeutic effect.
>
> Alexander Schauss (Gruson 1982), director of The American Institute of Biosocial Research, believes that color has a direct physiological impact: "The electromagnetic energy of color interacts in some still unknown way with the pituitary and pineal glands in the hypothalamus. These organs regulate and endocrine system, which controls many basic body functions and emotional responses, such as aggression". (Malkin, 1992, pp. 55-56).

The information presented in this chapter clearly testifies to the lack of evidence-based recommendations for color use in healthcare settings. On the other hand, in the search of the pertinent research literature we found numerous design guidelines. While these guidelines can be helpful in the marketplace, they often have been based on assumed truths, loosely tested research, case studies that cannot be generalized, intellectual folklore, intuition, and anecdotal experience.

Color Guidelines for Healthcare Environments

Guidelines typically offer "hypotheses" for the appropriate color for the environments at issue. Design guidelines often assert that using the recommended color may promote the well-being of the users within the particular setting. While we agree with Day, et al. (2000) who claimed that "Not all design guidance requires empirical research findings to justify its recommendations", empirical research is pertinent in at least three situations:

1. When recommendations conflict or contradict each other.
2. When causal explanation for the recommended design solution is unknown, or when the effectiveness of the recommendation is questionable.
3. When the recommendation has a major impact on the cost or on the quality of life of the users of the setting.

The literature that incorporates design guides for healthcare environments is quite extensive (Kleeman, 1981; Malkin, 1982, 1992; Spivack, 1984; Calkins, 1988; Hiatt 1990, 1991; Marberry & Zagon*,* 1995; Mahnke, 1996; Pile, 1997; Brawley, 1997; Leibrock 2000; and Regnier 2002).

Mahnke (1996) listed general design objectives for color and light design for healthcare facilities:

1. The facility must retain a dignified and respectful appearance, yet be attractive as well.
2. Color specifications must play a psychological and aesthetic role thereby:
   a. Promoting the healing process by guarding the physiological and psychological well-being of the patient;
   b. Being an aid in accurate visual medical diagnosis, surgical performance, and therapeutic and rehabilitation services;
   c. Enhancing light, visual ergonomics, supporting orientation, supplying information, defining specific areas, and improving working conditions through visual means.
3. Lighting must be chosen with respect to function, psychological reinforcement, visual appeal, color rendition, and biological concerns (1996, p. 148).

Mahnke's (1996) recommendations for mental health centers and psychiatric hospitals are:

1. Color specifications for mental facility corridors, patients' rooms, and examination rooms should follow the guidelines presented for other medical facilities in general. However, the emphasis must be on eliminating the "institutional look" even to a greater degree than in other medical facilities. The designer should strive to create a more "ideal-home" atmosphere.
2. Recreation areas, lounges, and occupational therapy rooms should be in cheerful, stimulating colors selected specifically to serve the function of each area. Some imagination should guide design choices in recreation areas—especially for children and adolescents.
3. Quiet or seclusion rooms should not look like punitive environments. If a patient is to be isolated, he or she should be in a cozy, inviting, sparsely and safely furnished space. This does not mean it should be barren—just simple and uncluttered. The room should give an impression of refuge, protection, and recuperation—not punishment. Sensory overload should be avoided and relaxation furthered by cool colors. Choose your colors carefully, so that they won't look institutional. Lighting should be on the warm side. Avoid lighting that is too uniform, that doesn't produce shadows. Shadows are a natural experience in the environment and help define the three-dimensionality of items. On the other hand, shadows should not be too extreme as to create effects that might be perturbing (Mahnke, 1996: 165).

Elizabeth Brawley (1997), provided the following three guidelines for using color in environments for people with dementia:

1. Exaggerate lightness differences between foreground and background colors, and avoid using colors of similar lightness adjacent to one another, even though they differ in saturation or hue. The lightness that you, the designer, perceive will most likely not be the same as the lightnesses perceived by people with color deficits, but you can generally assume that they will see less contrast between colors than you will. If you lighten the light colors and darken the dark colors, you will increase the visual accessibility of the design.
2. Choose dark colors from hues of blue, violet, purple, and red against light colors from the blue-green, green, yellow, and orange hues. Avoid contrasting lighter shades of the dark colors against dark variations of light colors (blue-green, green, yellow, and orange). Since most people with partial sight and/or color deficiency tend to suffer in visual efficiency for blue, violet, purple, and red, this guideline helps to minimize the ill effects of these losses on effective contrast.
3. Avoid contrasting hues from adjacent parts of the color wheel, especially if the colors do not contrast sharply in lightness. Because color deficiencies make colors of similar hue more difficult to discriminate, try to contrast colors from very different locations on the color wheel (p. 114).

Cynthia Leibrock (2000) provided guidelines for sub-acute care and rehabilitation. To substantiate her design guides, she accompanied her guidelines with citations:

- Appetite can be improved with warmer color choices for dining—for example, coral, peach, and soft yellow. Violet, yellow-green, gray, olive, and mustard are poor choices (Colby, 1990).
- Yellow to green tones should be avoided because they are associated with body fluids. Yellow, green, and purpose colors are not flattering to the skin and reflect jaundiced skin tones (Gappell, 1990).
- Use intense colors only for accents and for contrast to improve visual organization. Brightly colored grab bars, door-frames, levers, and switches, for instance, are easier to find those that blend into the background.
- Yellow color schemes may cause difficulties for people who have yellowing lenses. Bright yellow colors can intensify to the point of annoying. Pastel yellows are difficult to distinguish from white (which appears yellow).
- With yellowed lenses, blue, blue-green or violet color schemes may appear gray, especially in daylight or fluorescent light (in a blue color spectrum). Blue tones can be distinguished from other colors more easily at night when lighted by tungsten light (standard light-bulbs).
- Yellow tinting of the human lens has little effect on red tones. However, people with color-blindness have difficulty distinguishing between green and red.
- Texture makes tones appear darker (Hiatt, 1981), absorbing important ambient light.
- Color values that contrast by more than two digits on the gray scale are adequate to increase the imagery of objects (Hiatt, 1990). (The gray scale consists of ten increments from black to white; it is often illustrated on the back of many printer's rules.)
- A monochromatic color scheme throughout the building may be perceived as institutional. It can become monotonous and boring when viewed for an extended period. It can contribute to sensory deprivation, which leads to disorganization of brain function, deterioration of intelligence, and an inability to concentrate. For those who suffer from a deficiency of perception, plan variety in color, pattern, and texture.
- Warm color hues are often associated with extroverted responses and social contact. A quiet, relaxing, or contemplative atmosphere is created by cool hues.
- Primary colors (red, yellow, and blue) and strong patterns are pleasing at first but may eventually become tiring. Highly saturated colors may also be too controversial, triggering unpleasant associations in the mind of the guest (Carey, 1986).
- The boundary between two intense colors eventually becomes visually unstable (Pastalan, 1982).
- Researchers in the field of anthroposophic medicine maintain that color can help patients regain health. Patient rooms in warm colors are used to build up from a "cold" illness like arthritis, and cool blue or violet tones are used to dissolve or break down inflammation (Coates and Siepl-Coates, 1992).
- Color can affect perceptions of time, size, weight, and volume. In a space where pleasant activities occur, such as a dining or recreation room, a warm color scheme makes the activities seem to last longer. In rooms where monotonous tasks are performed, a cool color scheme can make time pass more quickly (p. 82).

Although not an exhaustive list, arguably the most frequently quoted color guidelines for healthcare were selected for further examination. The Content Analysis Table of Design Guidelines is a summary of design guidelines by Marberry & Zagon (1995), Marberry (1997), Malkin (1982, 1992), Brawley (1997), Leibrock (2000), Mahnke (1996), and Spivak (1984).

Content Analysis of Design Guidelines

	Marberry & Zagon (1995) Marberry (1997)	Malkin (1982,1992)	Brawley (1997)
Red	Its nature symbol is the earth, defined often by its qualities of high energy and passion. Studies have shown that red has the ability to excite and raise blood pressure.	Red and yellows, for example, should be used in settings where creative activity is desired and socialization encouraged...red may be appropriate in the depressed person's environment...red should be avoided for those afflicted with epilepsy and other neurological diseases.... (R)ed...should be used in an employees' restroom to reduce the amount of time spent there. Red and orange are commonly used in fast food restaurants, where quick turnover of tables is desired.	(On environments for persons with dementia) Red has an energizing quality appropriate for social spaces, such as dining rooms or visiting areas. Diverse cultures use red in different ways. The Chinese have always favored red, traditionally using it for the bridal gown—a sign of longevity.
Orange & Red Orange	Its nature symbol is the sunset, defined often by its qualities of emotion, expression, and warmth. Orange is noted for its ability to encourage verbal expression of emotion.	Red and orange are commonly used in fast food restaurants, where quick turnover of tables is desired.	Orange is capable of emitting great energy in its purest form and as an earth tone it evokes warmth, comfort, and reassurance. Orange and variations of orange, such as peach and salmon, are cheerful colors and are popular in dining rooms and healthcare environments.
Yellow	Its nature symbol is the sun, defined often by its qualities of optimism, clarity, and intellect. Bright yellow is often noted for its mood-enhancing properties. Yellow must be carefully applied in certain settings, as it causes thought associations of aging and yellow skin tones associated with jaundice.	Red and yellows, for example, should be used in settings where creative activity is desired and socialization encouraged.	Yellow evokes a sense of energy and excitement and its brilliance is most often associated with the sun. The emotional effects of yellow are optimistic and bright, yet sometimes unsettling and seldom restful. Yellow reflects more light than any other color and can be used to increase illumination in poorly lighted areas.
Green & Yellow Green	Its nature symbol is growth—grass and trees—defined often by its qualities of nurturing, healing, and unconditional love. Because it is the opposite on the visual spectrum to red, it is often thought of as a healer of blood... Using the opposite color of red (green) as the dominant color in operating rooms may lessen eyestrain for surgeons as they move the focus of their eyes from body tissue to the surrounding environment.	(G)reens and blues (should be used) in areas that require more quiet and extended concentration and high visual acuity.	Green, the color of plants and nature, represents growth and life and is associated with pleasant odors and tastes. Avoid yellow-greens and purples, if reflected on human flesh, will give it a sickly look. Yellow-green is the after-image of purple.
Blue	Its nature symbol is the sky and the ocean, defined often by its qualities of relaxation, serenity, and loyalty. It is known to lower blood pressure and is excellent as a healing color for nervous disorders. Due to its temperature being cool, it is also good for relieving headaches, bleeding, open wounds, and so on.	(G)reens and blues (should be used) in areas that require more quiet and extended concentration and high visual acuity.	Blue, of the three primary hues, is perhaps the most universally equated with beauty. Blue is timeless, linking the present with tradition and lasting values, and it is the most popular color with adults. Psychologically, blue is associated with tranquility and contentment. It is most commonly associated with the sky and the sea. Deep blue is considered to be the optimum color for meditation, for slowing down the bodily processes to allow relaxation and recuperation. Because of its calming effects, blue has long been a favorite for bedrooms.
Blue-Green / Aqua		Looking at a specific color produces an after-image of its complement. A practical application of this principle is the surgical operating room, where walls and garments are usually blue-green because the eye is concentrated on a red spot (blood); when surgeons look up from their work, they see after-images of cyan or blue-green because red and cyan are opposite each other on the color wheel. If walls and garments were white (in a surgical operating room), surgeons would see blue-green spots before their eyes every time they looked away from the operative site. Thus blue-green walls and apparel act as a background to neutralize afterimages.	

	Leibrock (2000)	Mahnke (1996)	Spivack (1984)
Red	Primary colors (red, yellow, and blue) and strong patterns are pleasing at first but may eventually become tiring.	Where patients are in therapy to regain the ability to walk, floors might be divided into sections of different colors....The first section could be red—the first steps are usually the hardest.	
Orange & Red orange		(On the labor room...blue-green) should be used as the dominant hue with subdued red-orange accents, or at least blue-green should be on the wall the patient is facing. Strong red-orange must be subdued, but not to a point where it appears dirty. ...Where patients are in therapy to regain the ability to walk, floors might be divided into sections of different colors....(after red) followed in sequence by orange, yellow, green, or blue.	
Yellow	Yellow to green tones should be avoided because they are associated with body fluids. Yellow, green, and purple colors are not flattering to the skin and reflect jaundiced skin tones (Gappell, 1990).	Where patients are in therapy to regain the ability to walk, floors might be divided into sections of different colors....(after red and followed in sequence by orange) yellow, green, or blue.	Institutional bathrooms often create a context filled with fecal and urine associations, for instance by using dark or brown tiled surfaces and/or dirty yellow paint under dim lighting....Colors should support accurate skin-tone perception...Yellows, greens and blues are particularly to be avoided as non-accent wall (background) hues.
Green & Yellow Geen	Yellow to green tones should be avoided because they are associated with body fluids. Yellow, green, and purple colors are not flattering to the skin and reflect jaundiced skin tones (Gappell, 1990).... Yellow color schemes may cause difficulties for people who have yellowing lenses. Bright yellow colors can intensify to the point of annoying. Primary colors (red, yellow, and blue) and strong patterns are pleasing at first but may eventually become tiring.	Intensive-care units and surgery corridors can be in cool colors, such as blue-green or green to reflect a functional and more serious atmosphere. These greens should not be too dark and weak, since such tones are often associated with "institutional green." (On EKG and EEG rooms) These rooms must not be arousing or exciting. Low-intensity blues or greens may be an effective aid in achieving this goal. However, this is a generality and the choice of tone is very important so that it does not result in monotony.	Colors should support accurate skin-tone perception...Yellows, greens and blues are particularly to be avoided as non-accent wall (background) hues.
Blue	Primary colors (red, yellow, and blue) and strong patterns are pleasing at first but may eventually become tiring.	(On hospital nursery) A blue wall may make an infant look cyanotic. ...Where patients are in therapy to regain the ability to walk, floors might be divided into sections of different colors.... Blue or green represent the final release of the difficult learning process. The association of the sequence would be appropriate; red being tension and blue or green being release.	Colors should support accurate skin-tone perception...Yellows, greens and blues are particularly to be avoided as non-accent wall (background) hues.
Blue-Green / Aqua		My concept of the ideal color for the labor room is a light blue-green. It should be used as the dominant hue with subdued red-orange accents, or at least blue-green should be on the wall the patient is facing. ... Intensive-care units and surgery corridors can be in cool colors, such as blue-green or green to reflect a functional and more serious atmosphere. ..Aqua and lower chroma greens are appropriate (in intensive care). However, be careful that it does not result in monotony. ...For years green and bluish-green have been used for gowns, caps, masks, and covers in surgery. This color reduces glare under intense light. It is the complementary of the red color of blood, thereby, neutralizing the afterimage produced by prolonged concentration on the wound. ...Recovery rooms can be lighter blue-greens, pale green, or aqua, but don't need to be. As stated before, quiet, relaxing surroundings can be achieved in many ways. Perhaps even a slightly warm color may pick up the spirits of the patient who has just undergone surgery.	

	Marberry & Zagon (1995) Marberry (1997)	Malkin (1982,1992)	Brawley (1997)
Blue-Green / Aqua (continued)			
Violet / Purple	Its nature symbol is the violet flower, defined by its qualities of spirituality. Violet is also a stress reducer and will create feelings of inner calm.		Avoid yellow-greens and purples, if reflected on human flesh, will give it a sickly look. Yellow-green is the after-image of purple. If one stares at purple then looks into a mirror or transfers his gaze to another, that person will look pallid (Birren 1983).
Neutrals	Traditionally, laboratories have been void of color, resulting from the misguided thinking that neutral gray or tan will not interfere with the concentration of researchers. While use of bright color on large surfaces may prevent accurate observation of materials being tested and analyzed (because of the reflectance factor), the proper balance of full-spectrum color should actually enhance the environment.	In patient rooms as well as staff areas, patterns should always be accompanied by a neutral wall to provide relief.	
White	When used in interior spaces, white creates a feeling of luminosity and clarity. Coupled with a full-spectrum color palette, white separates space and enhances the eye's ability to focus.	Evidence suggests that bland, monotonous environments cause sensory deprivation and are detrimental to healing. The brain needs constant change and stimulation in order to maintain homeostatis (stabilization of physiological functions). In addition, white walls cause considerable glare, which in turn causes the pupil to constrict. White walls have a clinical appearance that is unfamiliar and strange to most people; the absence of color is eerie. The combination of white walls, white ceiling, and white floor create strange perceptual conditions that can be very upsetting to patients trying to stabilize their balance or orient themselves.	White denotes purity and cleanliness and reflects more light than any other color. White can be used on all ceilings and overhead structures and in rooms where maximum light reflection is needed.
High-contrast	Elderly have difficulty seeing soft muted colors. When waking from an operation, some patients may have blurred vision. Also, anyone who needs visual aids, such as glasses or contact lenses, is probably not wearing them in the recovery area. Therefore, the postoperative setting requires art that has bolder and higher-contrast colors. ...To provide optimum contrast for people with low vision...maximize intensity/ reflectance contrast. Contrast dark colors with the opposite extremes of the hue scale, with tints from mid-value scale colors, and avoid contrasting light colors from the extremes of the hue scale against dark mid-value scale colors.	Strongly contrasting figure-ground patterns and extremely bright colors should be avoided in rooms of psychotic patients because these patterns—when not worn by the patients but impinging upon them from their environment—are thought to have an overwhelming, even intimidating, threatening effect.	(for persons with dementia)1. Exaggerate lightness differences between foreground and background colors, and avoid using colors of similar lightness adjacent to one another, even though they differ in saturation or hue. 2. Choose dark colors from hues of blue, violet, purple, and red against light colors for+D13 the blue-green, green, yellow, and orange. Avoid contrasting lighter shades of the dark colors against dark variations of light colors (blue-green, green, yellow, and orange). Since most people with partial sight and/or color deficiency tend to suffer in visual efficiency for blue, violet, purple, and red, this guideline helps to minimize the ill effects of these losses on effective contrast. 3. Avoid contrasting hues from adjacent parts of the color wheel, especially if the colors do not contrast sharply in lightness. Because color deficiencies make colors of similar hue more difficult to discriminate, try to contrast colors from very different locations on the color wheel.
Low-contrast	A patient undergoing various tests or convalescing might require softer, less contrasted works of art. ...Hues of similar saturation and value should not be placed side by side in facilities for the elderly.		

	Leibrock (2000)	Mahnke (1996)	Spivack (1984)
Blue-Green / Aqua (continued)		...(On laboratories) including sterilizing rooms, can be tan, pale green, gold, or aqua. Where color discrimination is critical n the work performed, walls must remain neutral—gray is advised. (On EKG and EEG rooms) These rooms must not be arousing or exciting. Low-intensity blues or greens may be an effective aid in achieving this goal. However, this is a generality and the choice of tone is very important so that it does not result in monotony. ... Those who found the "hospital green" of the past unpleasant because of its institutional associations can place white in the same category. Psychologists now are in general agreement that institutions should look anything but institutional.	
Violet / purple	Yellow to green tones should be avoided because they are associated with body fluids. Yellow, green, and purple colors are not flattering to the skin and reflect jaundiced skin tones (Gappell, 1990)... ...cool blue or violet tones are used to dissolve or break down inflammation.		
Neutrals		(On corridors)... the designer could lessen the information rate by keeping the walls neutral, with color added in incidental areas. The absence of color creates emotional sterility and may not be calming (or attractive)....(On laboratories) including sterilizing rooms, can be tan, pale green, gold, or aqua. Where color discrimination is critical n the work performed, walls must remain neutral—gray is advised. (On hospital nursery) Light hues, weak in chroma and toward the neutral side, such as pale beige or sand, are acceptable as long as adequate attention is paid to light-reflection ratios (not too high).	Fecal associations should be prevented...Institutional bathrooms often create a context filled with fecal and urine associations, for instance by using dark or brown tiled surfaces and/or dirty yellow paint under dim lighting.G20
White		During my many years of collecting reference material on color and light, I have not yet come across any pronouncement that supports white and off-white on psychological or physiological grounds for prompting its wide use. As early as 1947, Louis Cheskin pronounced: "White walls, as we know, are an optical strain and a psychological hazard." Over the years, this simple truth as been echoed again and again by many who have been concerned with color beyond its decorative value. In 1984, a West German government agency issued a study by Heinrich Frieling on color in the work environment. The study's conclusion about white walls: empty, neutral, no vitality.	
High-contrast	Color values that contrast by more than two digits on the gray scale are adequate to increase the imagery of objects (Hiatt, 1990). (The gray scale consists of ten increments from black to white; it is often illustrated on the back of many printer's rules).		Contrast (and color itself) is always a stimulus which attracts visual attention. Color and tone contrasts should be selected and placed so as to assist in clarifying and defining volumes, forms, edge changes and planes.
Low-contrast	Pastel yellows are difficult to distinguish from white (which appears yellow).	Brightness contrasts must be controlled, which means that the walls of the operating room should not exceed 40-percent light reflection (ideal is 30-35 percent); the floor should be 15 percent and the ceiling 80 percent.	Great contrast, either in color or tone, should not occur as an edge or line perpendicular to a movement path at floor level, except where there is an elevation change such as a step or ramp.

	Marberry & Zagon (1995) Marberry (1997)	Malkin (1982,1992)	Brawley (1997)
Low-contrast (continued)	The reason is that as people age, the lens of the eye turns yellow-brown, and hues of similar saturation and value next to each other become blurred, thus making it difficult to interpret environmental information (such as depth, contrast of objects, etc.		
Cool colors		Cool colors may be appropriate in environments for agitated, hypertensive, or anxious individuals; Highly saturated colors should be avoided with autistic schizophrenics; ...Under cool colors, time is underestimated, weights seem lighter, objects seem smaller, and rooms appear larger. Thus, cool colors should be used where monotonous tasks are performed to make the time seem to pass more quickly...Cool colors and low illumination encourage less distraction and more opportunity to concentrate on difficult tasks; an inward orientation is fostered. Noise induces increased sensitivity to cool colors, probably because the tranquility of these colors compensates for increased aural stimulation.	
Warm colors		Under warm colors, time is overestimated, weights seem heavier, objects seem larger, and rooms appear smaller... People become less sensitive to warm colors under noise because they offer additional stimulation rather than less.... "Health, according to anthroposophy, is a dialectical process of balancing tendencies toward 'sclerosis' (excessive hardening or building up—cold—illnesses) and inflammation or breaking down—warm—illnesses" (Coates and Siepl-Coates). Consequently, doctors prescribe warm- or cool-colored rooms based on the type of illness and stage of healing. C23	Large amounts of intense shades of warm colors can contribute to confusion and anxiety.
Value: Tints & Tones		In patient rooms, use colors that are flattering to skin tones near the patient's head; in patient bathrooms, use a light tint of rose or peach, in a shade that is flattering to skin tones, especially if fluorescent lighting is used around the mirror. Self-appraisal is important to a patient's morale: if lighting is poor and colors are unflattering to sk+C20in tones, patients may be shocked at their appearance.	Deeper tones of (red) rose and terra cotta combine the strength and energy of the earth to offer stability. ...As a pale tint (orange), it becomes the most flattering color of all to human skin tones. It leads people to believe that time passes quickly. ...In interior spaces, these qualities may need to be subdued through tinting, dulling or combining these colors with others. When tinted, yellow's brightness may be subdued, but it retains an appealing liveliness. ...Be careful using pale blue, however; by itself, blue can seem a bit too cool and unstimulating and for the elderly is more difficult to see. Experienced designers counteract these effects by balancing blue with warmer colors such as yellow or peach for freshness or red for an energizing effect. They reflect more light, help to compensate for low light levels and maximize the use of available light. They usually give D13 people a psychological lift. Small rooms, corridors, and spaces with few or no windows benefit from using light colors. Dark colors absorb light and can make a room appear smaller and more cramped. Darker tones can be quite dramatic, but in healthcare settings may be better used in lesser amounts. Prolonged exposure to large amounts of dark colors may contribute to monotony and depression.

	Leibrock (2000)	Mahnke (1996)	Spivack (1984)
Low-contrast (continued)		The wall color can be similar in hue (not brightness) to the color of the gowns and surgical sheets.	Sharp contrasts in the horizontal plane (as along a corridor or wall) should be avoided because they tend to exaggerate perspectives and body movements while walking.G36
Cool colors	A quiet, relaxing, or contemplative atmosphere is created by cool hues. Researchers in the field of anthroposophic medicine maintain that color can help patients regain health. Patient rooms in ... cool blue or violet tones are used to dissolve or break down inflammation (Coates and Siepl-Coates, 1992).· Color can affect perceptions of time, size, weight, and volume. In rooms where monotonous tasks are performed, a cool color scheme can make time pass more quickly (p. 82).	Quiet or seclusion rooms should not look like punitive environments. ... Sensory overload should be avoided and relaxation furthered by cool colors... Intensive-care units and surgery corridors can be in cool colors, such as blue-green or green to reflect a functional and more serious atmosphere. ...A cool (patient) room, for example, might have sandstone on three walls and pale green on the end wall. ...Since cool colors in general may be more conducive to relaxation and quiet, chronically ill patients should feel more at ease in light green or aqua. ...Never create a total unit environment in only warm or only cool hues (this applies to all areas of a health facility.). One atmosphere may predominate, depending on the section in question, but always introduce hues of the opposite color temperature somewhere in incidental areas or accessories. ...Reduced light levels are usual in intensive-care units, which need a restful and psychologically cool atmosphere.	
Warm colors	Appetite can be improved with warmer color choices for dining—for example, coral, peach, and soft yellow. Violet, yellow-green, gray, olive, and mustard are poor choices (Colby,1990). · Warm color hues are often associated with extroverted responses and social contact. Researchers in the field of anthroposophic medicine maintain that color can help patients regain health. Patient rooms in warm colors are used to build up from a "cold" illness like arthritis(Coates and Siepl-Coates, 1992). Color can affect perceptions of time, size, weight, and volume. In a space where pleasant activities occur, such as a dining or recreation room, a warm color scheme makes the activities seem to last longer.	For maternity and pediatric sections, warm colors are a good choice. The labor room shoul not exhibit strong colors, but perhaps also not too warm tones a the dominant choice. The room has to be relaxing and ease tension. ...A warm (patient) room could be pale orange on three sides eith the fourth wall slightly darker but not brighter. ...Never create a total unit environment in only warm or only cool hues (this applies to all areas of a health facility.). One atmosphere may predominate, depending on the section in question, but always introduce hues of the opposite color temperature somewhere in incidental areas or accessories. ......Aqua and lower chroma greens are appropriate (in intensive care). However, be careful that it does not result in monotony. ... Recovery rooms can be lighter blue-greens, pale green, or aqua, but don't need to be. As stated before, quiet, relaxing surroundings can be achieved in many ways. Perhaps even a slightly warm color may pick up the spirits of the patient who has just undergone surgery.	Walls and ceilings especially should be warm hues at high values and low chroma.
Value: Tints & Tones		If a single color is used (in patient rooms) on all walls, suitable choices are peach, soft yellow, pale gold, and light green...Fairly soft tones are better than sharp ones. For reasons of refinement, and because strong colors may be unduly unsettling or grow monotonous to a patient confined for a long term, caution must be exercised in purity of color. ..Since cool colors in general may be more conducive to relaxation and quiet, chronically ill patients should feel more at ease in light green or aqua. ...Recovery rooms can be lighter blue-greens, pale green, or aqua, but don't need to be. As stated before, quiet, relaxing surroundings can be achieved in many ways. ......(On laboratories) including sterilizing rooms, can be tan, pale green, gold, or aqua. Where color discrimination is critical n the work performed, walls must remain neutral—gray is advised....(On pediatric units) primarily clear and light colors, warm, friendly, and varied are called for. (On a hospital nursery) pink or blue walls, which might delight the parents, will not help nurses in their job of observation....Pink walls, by giving a false healthy look, may obscure the early tint of jaundice or obscure the real pallor anemia. ...In treatment rooms pale green or aqua are good choices for cardiac, cystoscopy, orthopedic, and urology procedures; pale coral or peach are suggested for dermatology, obstetrics, and gynecology.	

	Marberry & Zagon (1995) Marberry (1997)	Malkin (1982,1992)	Brawley (1997)
Chroma:Saturation levels	While use of bright color on large surfaces (in laboratories) may prevent accurate observation of materials being tested and analyzed (because of the reflectance factor), the proper balance of full-spectrum color should actually enhance the environment. Use of stronger color on surfaces where visual observation is not so critical, such as furniture and doors, is recommended.	Highly saturated colors should be avoided with autistic schizophrenics; ...Rousing, bright colors are more appropriate in environments for the aged than pastels, which are barely visible to those with failing eyesight....(Extremely bright colors should be avoided in rooms of psychotic patients because these patterns—when not worn by the patients but impinging upon them from their environment—are thought to have an overwhelming, even intimidating, threatening effect... Warm colors with high illumination encourage increased alertness and outward orientation; they are good where muscular effort or action are required, such as a physical therapy gym.	The intensity (of yellow) can be lowered through the addition of violet tones, making it earthy and reassuring. Bright colors, in their purer shades, compelling attract the eye, making objects appear larger and creating excitement. Bright colors complement basic wall colors and can be used as accent colors for doors, columns, graphics, clocks, and so on.
Color relationships	A balanced color palette will eliminate problems associated with using too much yellow (which tends to make patients look jaundiced). ...Avoid the use of any color against an achromatic color (white, gray, black) of similar value. Avoid contrasting hues from adjacent parts of the hue scale. Avoid contrasting colors of low chroma and similar value.	Another example of afterimage can be experienced by walking through a corridor that has yellow walls, a warm-toned floor, and incandescent (warm) light—essentially a yellow-hued environment. Leaving the corridor to enter a lobby produces afterimages of blue, the complement of yellow. ...Of the many possible ways of dealing with color in interior design, the following approach is suggested: 1. Consider the needs of each specific patient population that might affect the selection of color....2. Understand the laws of perception...3. Consider religious or symbolic associations with color, including cultural taboos, bias, and nationality, that may be relevant to the particular community (Hall,1973)...4. Read as many studies as you can find about the physiological effects of color... 5. Consider functional factors... 6. Understand how color affects the perception of space...7. Think about practical applications of color psychology....8. Consider aesthetics.	(On environments with dementia persons) When selecting color, decide on a color scheme of perhaps three to five colors. Dominant colors in one room can become accent colors in another. Variety can be expanded even further by using various shades and tints of the selected colors. ...Selection can be done in many ways; one of the most basic is to pick a color, then use the color wheel to make additional selections. The colors that harmonize best for the visually impaired will be the colors opposite on the color wheel. Start with color selections for the largest areas of color...

	Leibrock (2000)	Mahnke (1996)	Spivack (1984)
Chroma:Saturation levels	Use intense colors only for accents and for contrast to improve visual organization. Brightly colored grab bars, door frames, levers, and switches, for instance, are easier to find those that blend into the background. Highly saturated colors may also be too controversial, triggering unpleasant associations in the mind of the guest (Carey, 1986).· The boundary between two intense colors eventually becomes visually unstable (Pastalan, 1982).	For reasons of visual diagnosis the wall located at headboard end of the patient's bed should not carry highly saturated hues. These may alter the patient's skin color (reflection and simultaneous contrast). The wall the patient faces may serve as a different colored end wall to add interest and color change to the room....For reasons of refinement, and because strong colors may be unduly unsettling or grow monotonous to a patient confined for a long term, caution must be exercised in purity of color. (On hospital nursery) Light hues, weak in chroma and toward the neutral side, such as pale beige or sand, are acceptable as long as adequate attention is paid to light-reflection ratios (not too high).	Patients in their most vulnerable phases of illness, especially the manic and the schizophrenic, may find that rooms with strong and ubiquitous colors swamp their sensory systems. These patients...are confused with and hidden under a welter of "noisy" experiences....In this case, bright color, because of its presence everywhere in the room, even though it is relatively weak, presents a conflict between the signal and the noise. In the case where the background stimulus is so strong as to compete with signals...(it would give a) frightening experience of synesthesia; hearing colors, tasting them, or feeling them...a patient in the presence of overwhelming pink smells cherry blossoms.
Color relationships	With yellowed lenses, blue, blue-green or violet color schemes may appear gray, especially in daylight or fluorescent light (in a blue color spectrum). Blue tones can be distinguished from other colors more easily at night when lighted by tungsten light (standard lightbulbs). Yellow tinting of the human lens has little effect on red tones. However, people with color-blindness have difficulty distinguishing between green and red. Texture makes tones appear darker (Hiatt, 1981), absorbing important ambient light. A monochromatic color scheme throughout the building may be perceived as institutional. It can become monotonous and boring when viewed for an extended period. It can contribute to sensory deprivation, which leads to disorganization of brain function, deterioration of intelligence, and an inability to concentrate. For those who suffer from a deficiency of perception, plan variety in color, pattern, and texture.	1. The need to consider psychological and physiological effects in design for the well-being of the user must be explained to the client. He must be made aware that "personal taste" is not the major criterion. 2. The balance between unity and complexity, color variety within reason, must be respected. This balance depends on the visual information rate within a space produced in majority by dominant walls, subdominant (incidental surface areas, such as end walls, also flooring and ceiling), and accent color (furnishings—including decorative items), and color contrasts. 3. Visual ergonomics (agreeable seeing conditions) depend on the colors used and on contrast. Rules must be respected especially in the workplace, health facilities, industry, schools. 4. Satisfying the mood or atmosphere desired depends on the specification of colors based on their psychological content (effects, impression, association, synesthetic aspects (p. 129-130). (On nurses' stations) Regardless of the adjacent wall color, the back area of the station should be so color designed as to contrast with the other surroundings, This may be achieved through hue, chroma, or value contrast. An efficient tool that eliminate guesswork by bringing order to the many factors to be considered is the *semantic differential chart*, or polarity profile. The polarity profile pairs descriptive adjectives with their antonyms. These polarities provide a range of "feelings" about a space....Color design that serves a purpose has only three major rules:1. It supports the function of a building, and the tasks that are being carried out in it.2. It avoids overstimulation and understimulation. 3. It does not create negative emotional and physiological effects.	...paints, materials and other finishes should be clearly defined hues when seen under the actual illumination from full visual spectrum, sunlight-balanced, light sources. Color should be clear even if mixed. I question the wisdom of a philosophy which specifies that a different color paint, any color paint, should be applied to panels and trim in a standardized way, for engineering or any other purpose. ...By articulating surfaces, junctures of surfaces, their positions and distances, paint and/or wall covering color choices can clarify and simplify a chaotic environment.

Review of the content analysis of color recommendations provides an understanding of agreement, contradiction, and conjecture among the various authors. We found general agreement in the following areas:

- Authors accept the hypothesis that color can influence healthcare either positively or negatively and accept the premise that color can help to make the healthcare setting appear less institutional.
- Authors accept the notion that high-contrast colors assist in clarifying and defining volumes, forms, edge changes and planes. In some situations, high-contrast is called for, and in other situations, it is not.
- Most authors accept the hypothesis that too much of one color leads to harmful monotony.
- Most authors agree with the theory that the after-image of red (i.e., color of blood) is blue-green, and accordingly tend to recommend blue-green color for surgical operating rooms.
- Most authors agree with the premise that elderly people experience changes in their color vision.
- Most authors accept the hypothesis that color has the capacity to alter the sense of time—although how it is altered is debated.
- Most authors agree with the idea that weight and volume can be altered by color—warm colors make objects look heavier whereas cool colors make objects appear lighter.
- Most authors agree that color has the power to compensate for noise—cool colors are relaxing, warm colors offer more stimulation.
- Most authors accept the hypothesis that color has the capacity to alter room size with cool colors receding and warm colors advancing.
- Most authors are sensitive to the impact of color with skin tones—although it is debated which colors are better or worse.
- Most authors genuinely want to base their color choices on empirical research. As a result of the heavy cost of healthcare design and the pressure to support decisions with solid evidences, some aesthetic consideration in color selection processes may be compromised.

Conjectures and contradictions among the authors occur in the following areas:

- Various authors tend to develop their own series of hypotheses regarding color relationships.
- Various authors hypothesize that colors have powers relating to health although it is unsubstantiated and confusing in application. For example, avoid red with epilepsy and neurological diseases; red raises blood pressure; avoid strong colors for the manic and the schizophrenic; use red in therapy; use warm colors in patient rooms to build up from a “cold” illness like arthritis; use cool colors for breaking down inflammation and warm illnesses; use blue to relieve headaches, bleeding, and open wounds.
- Some authors reject colors that are associated with urine and fecal waste (i.e., yellow and brown) while others recommend the use of yellow for its powers of optimism and terra cotta for its energy of the earth offering stability. Further contradictions exist in what yellow can or cannot do: yellow is noted for mood enhancing; yellow is optimistic; yellow is sometimes unsettling; yellow can intensify to the point of annoying; yellow is to be avoided because of how it makes the skin look; yellow is to be avoided because of the association with urine.
- Some authors reject yellow, purple/violet, and yellow-green because of what these colors do to one’s skin tone. Some claim that these colors give a sickly look or jaundiced skin tones, while others see value in the use of the same colors. They argue that purple/violet tones are used to dissolve or break down inflammation and yellow evokes a sense of energy and excitement and its brilliance is most often associated with the sun and that it is a stress reducer and will create feelings of inner calm.
- Some authors assign emotional meanings to particular colors. Although these outcomes are unsubstantiated in the literature, some authors claim that red has qualities of energy and passion; yellow supports optimism; green provides unconditional love; blue promotes loyalty; and violet has spirituality.
- There are contradictory notions of the power of green. Some say green is a healer of blood and prescribe green because of its associations with nature, pleasant odors

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Inpatient Center
Hospice of the Central Coast
Monterey, California
Architect: *Anshen+Allen Architects & Chong Partners Architecture, 1994*

and tastes; green is helpful when extended concentration and high visual acuity is needed; and green should be used with chronically ill patients because it makes them feel more at ease. Others, however, reject green because it is not flattering to the skin and because of its institutional image.

- Some suggest that cool colors make time pass more quickly, others say that time is overestimated with cool colors.
- Contradictions occur in the use of white. White creates a feeling of luminosity and clarity, enhances the eye's ability to focus, denotes purity and cleanliness, and contributes to maximum light reflection. By contrast, white walls have a clinical appearance that is unfamiliar and strange to many people; the absence of color is eerie; white walls are an optical strain and a psychological hazard; they are empty, neutral, and have no vitality.
- Contradictions exist in the recommendations on tints and tones. Some say that deeper tones of rose and terra cotta combine the strength and energy of the earth to offer stability. Others recommend no graying agents be allowed to overcome the dimness that can threaten the enclosed environment common to institutional buildings and prolonged exposure to large amounts of dark colors may contribute to monotony and depression.
- Recommendations are contradictory regarding color intensity. Some say highly saturated colors are more appropriate for elderly than pastels and strong colors are good where muscular effort or action are required. Others argue that intense colors should only be used for accents and for contrast to improve organization because highly saturated colors may be too controversial and trigger unpleasant associations in the mind; they may be unduly unsettling or grow monotonous to a patient confined for a long term; in large areas may prevent accurate observation of materials being tested and analyzed; and they are bad for skin tones.
- Most authors provide recommendations without offering a hierarchy of principles to guide color specification. No guidance is offered for priority in reference to different recommendations. Skin tones, sense of time, type of illness or disability, after-images, monotony, noise, size of room, function of room, age and gender of the users, physical problems of environment (i.e., temperature, moisture, sunlight, etc.) and cultural and geographical differences, are all combined in one massive web of information. Consequently, conflicting recommendations are prescribed for the same functional spaces within the healthcare environment.

SUMMARY OF THE FINDINGS

What did we learn from the literature review, and what are implications of this knowledge on colors in the healthcare environment?

- There are no direct linkages between particular colors and health outcomes of people. The literature search could not elicit sufficient evidence to the *causal* relationship between settings painted in particular colors and patients' healthcare outcomes.
- No evidence for a direct connection between environmental colors and emotional states could be found in the literature. Specifying particular colors for healthcare environments in order to influence emotional states, mental or behavioral activities, is simply an unproductive practice. The outcomes of these efforts are unsubstantiated in the literature. It is not enough to claim what color can do for people; it is important to distinguish between the explicitly stated aim of such assertions and their latent function. Spaces do not become "active", "relaxing", or "contemplative" only because of their specified color.
- At the same time, there are demonstrable perceptual impressions of color applications that can affect the experience and performance of people in particular environments. There are indications in the research literature that certain colors may evoke senses of spaciousness or confinement in particular settings. However, the perception of spaciousness is attributed to the brightness or darkness of color and is highly influenced by contrast effects particularly brightness distinctions between objects and their background.
- While studies have shown that color-mood association exists, there is no evidence to suggest a one-to-one relationship between a given color and a given emotion. In spite of contradictory evidence, most people continue to associate red tones, for example, with stimulating activities and blue tones with passivity and tranquility. Clearly, colors do not contain any inherent emotional triggers. Emotional responses to colors are caused by culturally learned associations and by the physiological and psychological makeup of people.
- The popular press and the design community have promoted the oversimplification of the psychological responses to color. Many authors of guidelines tend to make sweeping statements that are supported by myths or personal beliefs. Likewise, most color guidelines for healthcare design are nothing more than affective value judgments whose direct applicability to the architecture and interior design of healthcare settings seems oddly inconclusive and nonspecific. The attempt to formulate *universal* guidelines for appropriate colors in healthcare settings is ill advised. The plurality or the presence of multiple user groups and subcultures, and the complexity of the issues of meaning and communication in the environment make the efforts to prescribe universal guidelines a waste of energy. Consider, as an example, the issue of communication in the context of color in present healthcare settings: Designers may attempt to endow the settings with cues that the users may not notice. If the users notice the cues, they may not understand their meaning, and even if they both notice and understand the cues they may refuse to conform.

- Since colors are experienced in the real world where complex orders interact with the perception and behavior of people, they need to be studied in a context in which geometry, color, texture, light and other design attributes can be controlled and detected. Tests in isolated, sterile laboratories are perhaps helpful for initial color studies, but they lead to impoverished perceptions of the reality.
- The study of color in healthcare settings is challenging because it occurs in the context of meaningful settings and situations. When we are exposed to a color in a certain setting, our judgment is a result of a reciprocal process that involves several levels of experience. In order to specify colors for any setting, we need to recognize that humans react to color on different levels. Some of these reactions are cognitive. Others depend on perception, whereas other reactions are physiologically triggered. Analysis of color in any environment means respecting other kinds of processing forces such as culture, time, and location. But, while the detection of the psychological response to color is imperative, the visual pathway from the eye to the brain is an important variable for the understanding of color design.
- The literature review can teach us what to avoid in the process of specifying colors for healthcare settings. Beach, et al. (1988) were very explicit in their criticism:

  > It is not sufficient to hire “good interior designers” and take their best judgments about appropriate colors. Designer’s insights, heuristics and principle of practice are notoriously contradictory, and often have keyed on the wrong dimensions of color. Their choices are also based on historical considerations and style distinctions that are often quite irrelevant for their clientele. While an experienced designer can usually synthesize explicit criteria for interior color into a masterful solution, careful programming of the behavioral color requirements for different spaces ought to precede this task (p. 115).

- While users of healthcare settings should be allowed to contribute to the color selection whenever it is possible, the process should not be focused solely on satisfying people’s preference. Rather, the specification of colors should center first on the role of the color in the environment and the intended activities in the space. The performance specification should be the starting point for the designer who should be allowed to create color combinations for the sake of the users that drew both on art as well as science.

DISCUSSION

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Hematology Waiting Room
Cardinal Glennon Children's Hospital
St. Louis, Missouri
Interior Designer: *Directions in Design, 1997*

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Laboratory
Anheuser Busch Eye Institute
St. Louis, Missouri
Architect & Interior Designer: *HOK Architecture & Directions in Design, 1994*

In the final section of this manuscript we want to come back to the two fundamental questions that directed this project. First, "What is empirically known about human response to color and how, if at all, color influences human perception or behavior in a specific setting?" The simple answer is: very few.

To the second question, "Which color design guidelines for healthcare environments, if any, have been supported by scientific research findings?" the answer is: hardly any. Clearly, there are no reliable explanatory theories in this field.

The answers may disappoint many, particularly practitioners in the healthcare design community because of the expectations to identify theories, which could have had "supportable design implications for the use of color in healthcare design". Unfortunately, the results of the critical review of the pertinent literature on color produced very little scientific explanation for the issues at stake. Similarly to other fields, explanatory theories may help to predict outcomes of environmental interventions. Thus, analogous theories in color studies could, perhaps, predict how color might influence people in healthcare settings. But this class of theories is almost non-existent in this field. Therefore, much of the knowledge about the implications of color in healthcare environments is based on highly biased observations, and pseudo-scientific assertions. It is this inconsistent literature that has been spun to capriciously color trends in the healthcare market.

Color Theory

Color Theory is an ambiguous term. It addresses the chemical, physiological and psychological aspects of the study and application of color. It combines scientific explanations based on empirical studies with personal assumptions grounded in individual experiences and observations of human behaviors. The body of literature on color spans the disciplines of art, architecture, the physical sciences, behavioral sciences, and the combination of these fields.

Obviously, some aspects of *Color Theory* are by definition objective, while individual reactions to color may be plainly subjective. Two fundamental problems arise from this notion. First, since human reaction to color is based on freedom of choice it may preclude us from providing scientific explanation for much of our observations, because intentional human behavior cannot be explained in the same way we can explain natural phenomena. It has to include *interpretations of meanings*. The reason is that color-selection, specification, and application are acts that are performed because of their *meanings*.

The second question has to do with the nature of theory. While the definition of the term *theory* is not universally agreed upon, the volume of information that designers, artists, and color consultants consider as color theories have little in common with the attributes of explanatory theories as discussed, for example, by Rapoport (2000). Scholars distinguish between positive (analytic, predictive) theories and normative (creative) theories (Lang, 1987; Hillier, 1996). Analytic theories are analogous to scientific theories. Theories in science are sets of general, abstract ideas through which we understand and explain the material phenomena the world offers to our experience. They deal with how the world *is*, not how it *might be*.

Normative theories, on the other hand, consist of statements on what ought to be. As Lang (1987) explains: "The scientific method provides rules for description and explanation, not for creation. A design may be derived from scientifically formulated positive theory, but this does not make it scientific. Normative theory is based on an ideology or world view even if this is not explicitly stated " (p. 16).

Color-selection and specification are obviously part of the design process. Because the design process is creative, it requires theories of possibility in the sense that they exist in art. However, because the design process is also predictive, it needs the analytic theories of actuality and possibility. Environmental design is based on a cyclical process that involves creative as well as predictive phases. The creative and predictive phases of the design process explain the need to use normative and analytic aspects of theories. The normative aspects of a theory tell the designer where to search for possible solutions in the creative phases, whereas the analytic aspects inform the designer how the solution will work.

Like other theories in environmental design, color theories have too often been strongly normative and weakly analytic, that is, it has been too easy to use them to create guidelines and prescriptions for action, but they are too weak in predicting what the settings will be like when completed and how its colors will influence the users.

Color Studies and the Scientific Approach

The Coalition for Health Environments Research's (CHER) expectations from this literature review have been based on the idea that careful analysis and comprehensive knowledge leads to better design outcomes, or at least better than the ones that may be achieved through an intuitive practice. The expectations for a "good theory" have been grounded in the idea that *science* is the only approach to explain and understand the world and the way it works.

Replacing the intuitive design process, dominated by imagination, by using reason-based procedure, is not a new initiative. Since the 1960s scholars (Alexander, 1964; Archer, 1970; Bazjanac, 1974; Salvadori, 1974; Zeisel, 1981) have attempted to develop models for understanding the design process. Their assumption has been that the principles of scientific methods can be applied to the design process. On the whole, these representations are based on models of decision-making in other fields (Simon, 1969).

The premise has been that to better predict design outcomes, designers should draw on ever expanding theoretical knowledge instead of using solely aesthetic expressions as Jon Lang (1987) noted: "Good predictions depend on good theory about the phenomenon that is under concern" (p. 45). The origin of this approach can be traced all the way to Descartes' conception of rationality, which has dominated much of the Western thinking ever since the 17th century. "Descartes' innovation consisted in attempting to replace authority with reason. He undertook to found science upon a principle that would rationally justify itself and therefore stand as more than a tenet of faith" (Rochberg-Halton, 1986, p. 73). Adopting these ideas for the field of environmental design introduced one of the fundamental controversies of modernity into architecture, as Hillier (1996) notes:

> Descartes' objective was very similar to that of the twentieth-century design theories. Descartes wanted to rid the mind of the clutter of preoccupations embodied in natural language, and, starting only from indubitable, simple notions, to rework the whole structure of human knowledge. His model was geometry, where we begin from a small number of indubitable (as he thought) postulates and axioms, and use them to create chains of reasoning (theorems, lemmas, proofs, and so on) and eventually large structures of secure knowledge (pp. 414-15).

The problem with Descartes' principles is that they have been intellectually perfectionistic. These principles are notorious for cutting away the "inessentials" in order to identify "the abstract core of 'clear and distinct' concepts needed for its solution. Unfortunately, little in human life lends itself fully to the lucid, tidy analysis of Euclid's geometry of Descartes' physics" (Toulmin, 1990, p. 200). In other words, the rigor of scientific theory is useful only up to a point and only in certain circumstances. The quest for certainty is, perhaps, appropriate within abstract theories, however all abstraction involves omission of elements that do not lie within the scope of a given theory. "Once we move outside the theory's formal scope, and ask questions about its relevance to the external demands of practice, however, we enter into a realm of legitimate uncertainty, ambiguity, and disagreement" (Toulmin, 1990, p. 200).

Despite the limitations of pure scientific approaches in environment and behavior studies, several scholars argue that the only way this field can make progress is by developing explanatory theories. Amos Rapoport (2000), for instance, claims that because of the significance and value of explanatory theories, he has been "calling for a shift away from an art metaphor of design to a science metaphor" (p. 110).

What are explanatory theories? Metaphorically described as maps, theories are “sets of interrelated high-level principles or concepts that can provide an explanatory framework for a broad range of phenomena in a domain” (Rapoport, 2000, p. 112). A “good theory” is simple, elegant, and contributes to the “economy of thought”. It enables “people to derive a large number of descriptive statements from a single explanatory statement” (Lang, 1987, p. 14). But, theory building involves more than describing the world. Explanatory theories can contribute to our understanding why things are the way they are, and why the world (or the issue in front of us) is the way it is. In spite of the ambiguous demarcation criterion that distinguishes between science and non-science, that is why scientific explanations have vast practical value. For example, scientific explanation can assist us when we want to explain the occurrence of diseases in order to prevent them or cure them. Scientific explanation can reduce the biases that come from the casual observations we make everyday and help us to better predict outcomes.

When we search for scientific explanation, we ask for factual information. There are, however, several other kinds of explanations, many of which are not scientific (Salmon, 1998). For example, when people repeatedly ask what is the meaning of the white color in a wedding ceremony or the meaning of the black color in a funeral service, we may explain the meanings by reference to iconography of the Western culture. However, *explanations of meaning* are rarely used as scientific explanations. Another kind of explanation has to do with *learning how to do something.* For example, a color-coded floor plan of a hospital, placed in its lobby might explain how to find a particular unit in the hospital maze. These types of explanations would not normally be requested by posing why-questions. However, when we speak of *scientific explanation,* we generally ask *why certain phenomena occur*. In many cases, if not always, in order to explain a fact, we need to identify its cause. In other words, our *intellectual understanding* of the world, which derives from scientific explanation, is always *causal*. For instance, we need to know the causes of falls in nursing home environments in order to reduce their occurrence or to prevent elderly from falling. Or we want to know the *cause* for using particular colors in specific areas of the healthcare environment in order to improve the performance of users of these settings.

However, our literature review revealed very little scientific explanations of the kind that lead to *causal* understanding. A good number of the studies we examined, provided *teleological* explanations or *functional* explanations (Salmon, 1998). These explanations make references to human motives, purposes or goals, which traditionally have been avoided in the conduct of research in the natural sciences. On the contrary, the application of color in healthcare environments is an intentional human behavior, which needs to be studied in the context of human sciences. As such, the use of functional explanations in this context is clearly rational because it inevitably includes peoples’ interests, objectives, beliefs, and feelings (Taylor, 1980).

The risk is, of course, when functional explanations are used to explain causal relations that are, at best, questionable or subjective. We are told, for instance that red is exciting, purple is stately or mournful, yellow is joyful, green is calming, etc. Color consultants tend to repeatedly predict specific outcomes for certain colors used in healthcare environments. For example:

> Carefully adjusting the brightness to softer colors of the same hues helps avoid monotony, and in addition keeps the eyes from being distracted, causing them

> to work overtime and produce fatigue (Brawley, 1997, p. 108).
>
> Orange. Its nature symbol is the sun, defined often by its qualities of emotion, expression, and warmth. Orange is noted for its ability to encourage verbal expression of emotion (Zagon, in Marberry, 1997, p. 229).
>
> The right colors can help to change moods from sad to happy, help dispel loneliness, encourage conversation, and create a sense of peace and well being (Brawley, 1997, p.118).

The problem with these debatable statements is our inability to attribute the outcomes of the human reaction to the prescribed colors. Consequently, these statements are nothing more than affective value judgments whose direct applicability to the architecture and interior design of healthcare settings seems oddly inconclusive and nonspecific. Because it is not enough to claim what color can do for people; it is important to distinguish between the explicitly stated aim of such assertions and their latent function, as Salmon (1998) notes:

In a period of drought, for example, a group of people might perform a rain dance. Although the explicit purpose is to bring rain, the ceremony has no causal efficacy with respect to this goal. Even if rain occurs, it cannot be attributed to the performance (p. 84).

This cautionary advice is echoed in Lorraine Hiatt's (1991) discussion of color in long-term care settings when she argued: "What I take issue with is the notion that there is one color scheme that is going to return the memories of older people; color that will make them dance again or for the first time".

Thus, we naturally become suspicious when a color consultant prescribes a pink color for a patient room in order to influence her recovery from a surgery. The claim that the color of the room caused the recovery is an incomplete explanation. Because, we have reason to believe that there are additional relevant factors, as yet unknown, that have contributed to the remarkable recovery. In our quest for understanding, we want to establish a *causal* account for the recovery. Therefore, we first look for evidence in the past in which the presence of a pink color contributed to the recovery of a patient. If the color has had a result or a consequence in past recoveries, it can help us to establish a *causal* account. However, it is important to notice not just whether a particular color choice has had certain consequences in the past, but whether the choice of a specific color is *causally* responsible for the patient healthcare outcomes in the present instance.

In our literature review we could not find studies that provide *causal* explanations for the effects of colors on people in healthcare environments. In other words, we did not find sufficient evidence in the literature to the causal relationship between settings painted in particular colors and patients' healthcare outcomes.

Understanding Meanings

As we have already noted, the understanding of meanings is central to the studies of color. The problem of understanding meanings of color appears in various contexts such as language, rituals, symbols, concepts, art objects, and environmental design. While the natural sciences since Galileo had succeeded by ignoring any meaning their objects have had for human beings, in the human sciences, these meanings are precisely what we need to understand (Rouse, 1987). The understanding of meanings of color in a wide range of contexts may help us to understand part of the world of human activity. Therefore, ignoring human conscious and unconscious behavior in studies that seek to explain the psychological and physiological effects of color on people is clearly pointless. As Salmon (1998) notes:

> One view of human behavior is that, because it is meaningful—that is, purposive or intentional—scientific explanation does not yield understanding of it. Rather, understanding requires interpretation of meanings. This view is closely associated with the idea that human behavior cannot be explained causally because it must be understood in terms of reasons, and reasons are not causes (p. 8).

In order to understand a person's behavior we need to know his or her motives, values, desires, beliefs and purposes. If we understand the person we may be able to predict that person's emotional reactions and behavior. However, human beings are free agents and therefore predictability may be problematic. Thus, to predict how a particular person may react to specific colors, which are supposed to contribute to his or her healing process may be very difficult. Moreover, to predict how different people from diverse backgrounds with various motives, values, desires, beliefs and purposes will react to prescribed colors in healthcare environments is perhaps pretentious and impractical.

Clearly, any satisfactory understanding of human behavior in reference to color requires interpretations of meanings. Herbert Blumer formulated in the late 1930s the term "symbolic interactionism" in his attempt to further social theory. The theory claims that meaning forms the very basis of society and that the foundation of meaning is the sign or symbol. Blumer (1969) summarized the essence of the theory in three basic premises:

> The first premise is that human beings act toward things on the basis of the meanings that the things have for them … The second premise is that the meaning of such things is derived from, or arise out of, the social interaction that one has with one's fellows. The third premise is that these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things he encounters (1969, p. 2).

If we accept these premises, we can conceptualize the issue of color in healthcare design as a set of cues that are part of the situational context of meaning. This view emphasizes "meaning as a communicative process located in interpretive acts, whose study demands close attention to the uniqueness and variability of situations as well as to the way situations reflect habitual attitudes of mind" (Rochberg-Halton, 1986, pp. 43-44). The strength of this approach to meaning is perhaps its emphasis on the living process of interpretation, which gives novelty, uniqueness, and an individual character to a situation. What is important about the subjective interpretation in reference to color in the healthcare environment (as in other environments) is that the person can integrate the interpretations with the ultimate goals of his or her existence as a member of the wider community.

The study of color in healthcare settings is challenging because it occurs in the context of meaningful settings and situations, “whose interpretation is always potentially open to challenge based upon different interpreters’ interests, situations, or prior beliefs” (Rouse, 1987, p. 46). When we are exposed to a color in a certain setting, our judgment is a result of a reciprocal process that involves several levels of experience. We first acquire direct sensuous information through our visual perception. This input is analyzed against our background of cognitive information on that environment and that particular color which we have obtained from our culture. The consequence of this process is dialectical: “cultural standards modify perception and perceptual input, in turn, modifies our aesthetic response” (Fitch, 1988, p. 5).

But this process does not take place in a vacuum. It occurs within a web of experiential conditions, which inevitably modifies our judgmental process. Thus, if the healthcare setting is too noisy, or too cold, or the place is cluttered with all kinds of medical equipment and bad odors, the aesthetic experience of our response to its color will be affected, regardless of its “objective” meaning. In addition, our response is influenced by our role in the settings (whether we are patients, staff members or visitors to the facility). Furthermore, a large host of internal forces are involved in the act of reaching aesthetic conclusions. Among them are our physical condition (i.e., whether we feel sick or suffer from pain, how tired we are, whether we lay in bed or work out as part of our physiotherapy, etc.) as well as our psychological state (i.e., whether we are aware of our surroundings or we are under the influence of drugs, or whether we are anxious about certain medical procedures, or suffer from dementia, etc.).

Based on this short analysis it is clear why the general laws that cover the individual’s response to color will continue to be difficult to formulate, and the reasons that there is no guarantee that we will be able to reach an agreement over the interpretation of meanings of color in healthcare environments. But the problem is part of the larger question of culture-environment relations, which stems from significant changes in the context of design and the cultural responsiveness to it. This important topic is the focus of our conclusions.

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Cancer Hospital and Research Institute
University of Southern California
Los Angeles, California
Architect: *Anshen+Allen Architects & Orlando Diaz-Azcuy Design, 1996*

CONCLUSIONS

In conclusion we want, first, to reiterate our claim that the use of color in healthcare settings, currently is not based on significant research. Obviously the normative statements in the form of prescriptions for color in particular environments need to be supported by better understanding. In other words, “explanatory theory needs to precede normative statements which should be based on such explanatory theory” (Rapoport, 1987, p. 12). If we want to have evidence-based guidelines, we need to understand what particular colors are supposed to do, and why, before we can proceed to implement them in a healthcare setting and before we can judge whether these colors do it well. As Rapoport (1987) argues: “The validity of objectives must be evaluated before one evaluates whether objectives have been achieved” (p. 12).

Second, we suggest that the attempt to formulate *universal* guidelines for appropriate colors in healthcare settings is ineffectual. The plurality or the presence of multiple user groups and subcultures, and the complexity of the issues of meaning and communication in the environment make the efforts to prescribe universal guidelines an unproductive undertaking. Consider as an example the issue of communication in the context of color in present healthcare settings. Designers may attempt to endow the settings with cues that the users may not notice. If they notice the cues, they may not understand their meaning, and even if the users both notice and understand the cues they may refuse to conform (Rapoport, 1987). Therefore, our efforts need to concentrate on the *particular* through the formulation of explanatory theories and empirical studies with the aim to give attention to specific and concrete problems rather than abstract and universal questions. Our focus needs to be on problems that do not occur generally, but come about in particular types of situations.

Third, we need to return to the *local*, and study systems, practices, and experiences in their local context of their traditions. We need to look at the ways they are embedded in their milieu instead of aspiring to test their universal validity. In other words, we need to identify and define the groups for whom we design and prescribe colors. Because there are so many groups of users with different cultures in present healthcare settings, we need to identify these groups and design for (and with) these specific *users*. We need to understand the society and the culture against which our interpretation takes place. At the same time, we need to look at the problems and the solutions we study in their temporal or historical context, and to explain them from this perspective. As designers, we need to *discover* what is important rather than *assume* that guidelines can cover every possible eventuality and provide solutions for all design challenges.

And, last but not least, we need to match up the methods that should be used to study and realize color in healthcare environments. The methods should be appropriated for the study of “meaning” and “interpretation”. Simultaneously, these methods should be able to meet the challenge of validity (Flick, 2002). At the same time we have to remind ourselves that while it is important to study the topic of color in healthcare settings, to know the facts and the pertinent literature, that alone is not sufficient. Whether this information is used depends on how designers define the domain of color in healthcare environments.

Clearly, the research of color in healthcare environment is an important endeavor. Yet, the subject matter is complex and multifaceted. Furthermore, mastering this knowledge for the application of research findings in healthcare settings requires caution and sensitive creativity is paramount.

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Study Questions

1. Newton distinguishes among the seven hues of the color spectrum because
- **a)** he was color blind
- **b)** he assigned seven hues based on the seven notes of the musical scale
- **c)** it has been empirically proven that light contains only seven distinct visible hues

2. Based on the findings in the reviewed studies, the arousal effects of color suggests that
- **a)** blue rooms will have a calming influence on hospital patients
- **b)** these effects are neither strong, reliable, nor enduring for predictable behavioral outcomes
- **c)** can be predicted as long as the hue, value, and intensity of that color can be controlled

3. Improving thermal comfort of people by changing color of surroundings
- **a)** may occur at the psychological level although it is not accompanied by detectable physical reactions
- **b)** works for most people
- **c)** is recommended in all health care settings

4. Research on color preference suggests that it
- **a)** has universal substantiated truths
- **b)** is unrelated to inducing specific moods
- **c)** is an abstract dimension that is unrelated to cultural background

5. Color needs to be studied in context of real settings in which geometry, color, texture, and light can be controlled because
- **a)** laboratory research is limiting
- **b)** of the meanings that people assign to colors
- **c)** cognitive processes, individual background, education, experience, socio-cultural background, and personal taste need to be considered
- **d)** all of the above

6. Authors of publications on color generally agree that
- **a)** high-contrast colors assist in clarifying and defining volumes, forms, edge changes and planes.
- **b)** elderly people experience changes in their color vision
- **c)** perception of weight and volume can be altered by color
- **d)** all of the above

7. Contradictions among authors who write about color occur
- **a)** in relating the treatment of illnesses with the application of specific colors
- **b)** in rejecting the specification of certain paint colors (e.g., white) for health care settings
- **c)** in recommendations on tints and tones of colors
- **d)** all of the above

8. The general laws that cover the individual's response to color
- **a)** will continue to be difficult to formulate
- **b)** will not guarantee that we will be able to reach an agreement of the interpretation of meanings of color in healthcare
- **c)** are part of the larger question of culture-environment relations which stems from significant changes in the context of design and cultural responsiveness to it.
- **d)** all of the above

9. Trends and fashion always influences the application of colors
- **a)** to increase sale of products
- **b)** because research and technology require change every year
- **c)** to adapt design of built environment to new needs of consumers

10. There are direct linkages among particular colors and health care outcomes. (T/F)

11. Most color guidelines are based on empirical research and can be formulated into universal guidelines for designers. (T/F)

12. There are demonstrable perceptual impressions of color applications that can affect the experience and performance of people in health care environments. (T/F)

13. Colors may evoke a sense of spaciousness or confinement. (T/F)

14. Red tones stimulate activities and blue tones induce passive behavior. (T/F)

15. Users of health care settings should not be allowed to contribute to the color selection. (T/F)

Qualifications of Authors

Ruth Brent Tofle, Ph. D. is Professor and Chair of the Department of Architectural Studies (formerly Environmental Design) at the University of Missouri in Columbia, Missouri. Following her Ph. D. from the University of Minnesota, she received a post doctorate fellowship from NIMH, ASID Environmental Design Award, and Fulbright Fellowships to China, Morocco and Tunisia. She participated in faculty exchanges in Thailand and Korea and was President of the Missouri Fulbright Alumni Association. With research interests in environmental gerontology and place attachment, she has co-edited *Aging, Autonomy, and Architecture: Advances in Assisted Living* and *Popular American Housing*, guest edited two issues of *Housing and Society*, guest edited the Journal of Architectural and Planning Research, authored software *"Home Safe Home*", and published over thirty publications. She has had national appointments with the American Society of Interior Designers and Interior Design Educator's Council, and has served as associate editor and/or reviewer for several professional journals. She was NCIDQ certified in 1994, Registered Commercial Interior Designer in the State of Missouri in 2000, LEED Accredited Professional in 2004, and since 1984 has been a Department Chair.

Benyamin Schwarz, Ph.D. is a Professor in the Department of Architectural Studies at the University of Missouri-Columbia. His teaching specialty areas include design fundamentals, housing concepts and issues, design studio, architectural programming, and environmental design for aging. He received his bachelor's degree in Architecture and Urban Planning from the Technion, the Institute of Technology of Israel, and his Ph.D. in Architecture from The University of Michigan with an emphasis on Environmental Gerontology. He designed numerous projects in Israel and in the U.S. His research addresses issues of long-term care settings in the United States and abroad, environmental attributes of dementia special care units, assisted living arrangements, and international housing concepts and issues. Dr. Schwarz is the editor of the *Journal of Housing for the Elderly* and the author of *Nursing Home Design: Consequences of Employing the Medical Model.* He co-edited with Leon A. Pastalan, *University-Linked Retirement Communities: Student Visions of Eldercare* and *Housing choices and well-being of older adults: Proper Fit.* He co-edited with Ruth Brent, *Popular American Housing: A Reference Guide* and *Aging Autonomy and Architecture: Advances in Assisted-Living*. His most recent edited book is *Assisted Living: Sobering Realities*.

So-Yeon Yoon, MA, is Resident Assistant Professor in the Department of Architectural Studies at the University of Missouri-Columbia. Her expertise is in graphic interface design and web authoring. She received her bachelor's degree and master's in Interior Design from Pusan National University in Korea, and second master's in Environmental Design from the University of Missouri-Columbia. Currently she is Ph.D candidate in Information Science and Learning Technologies with an emphasis on User Interface Design at the University of Missouri. As a Graphic Designer and Interface Usability Specialist, she directed web design projects for a number of companies including Hyundai Heavy Industries. Since 1998, she has taught visual design, design communications, web design, animation, multimedia design, and virtual reality design at the University of Missouri-Columbia and the University of Ulsan, Korea.

Andrea Max-Royale, MEDes. is a faculty member and incoming Chair of Interior Design at Lakeland College, Canada. Her teaching encompasses the senior design studios, construction fundamentals, building systems, as well as architectural drafting. After completing her Master's degree from the University of Calgary, Canada, her design experience stretched from furniture to private residential then further to urban planning, completing two riverfront marketplace developments in the province of Saskatchewan. Previous research has included color and place relationship, with particular focus on rural Saskatchewan. The development of color palettes and their acceptance into the built environment remain an integral part of Andrea's repertoire after years of private residential color consulting. This has stemmed into further interest and research in the relationships between the expression and interpretation of space and individual traits, lifestyle and culture: the perception of our relationship with our environment and who we are as people.

Coalition for Health Environments Research

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COALITION FOR HEALTH ENVIRONMENTS RESEARCH

What is CHER?

The Coalition for Health Environments Research (CHER) is made up of a group of proactive organizations whose mission is to promote, fund, and disseminate research to help create more humane, effective, and efficient environments through multidisciplinary collaboration dedicated to quality healthcare for all.

We are led by a volunteer Board of Directors and Research Council, and guided by a Provider Council. Board members are generally individuals from member organizations who have a passion for and commitment to our mission: the desire to understand the healthcare field, use research for guidance, and willingness to take on specific assignments to further our goals.

Research Council members are experienced researchers from the disciplines of architecture and healthcare. Their task is to help set CHER's research agenda and maintain high standards for selecting researchers, methodology, and results reporting.

Provider Council members are representatives from healthcare providers who offer advice and counsel on the continually evolving research agenda and assist in prioritizing that agenda on a yearly basis.

Why CHER?

Today, many hospitals and healthcare facilities are planned without a sufficient base of scientific or other objective research data. Healthcare executives, consultants, architects, and interior designers must make multiple complex decisions during the course of planning for new buildings or renovations. Many buildings are based on current trends, code minimums, cursory reviews of recent projects, and popular theories. Objective studies or evaluations of results for health environments, patient outcomes or operational efficiency are virtually absent.

Coalition for Health Environments Research

In addition, the U.S. spends more on healthcare construction than most other countries in the developed world, yet it ranks among the lowest in terms of national commitment by its government to health environments research. CHER aspires to be a catalyst for the private sector and governmental agencies to foster a significantly greater level of research and results dissemination on a national scale. This is no small undertaking.

What does CHER do?

With the help of private and public sponsors, we initiate projects to address critical research questions. Examples of recent projects include:

With the help of private and public sponsors, we initiate projects to address critical research questions.

The Nature and Rate of Change in Hospital Laboratories
In responding to the accelerating change in the healthcare field, there has been a great deal of attention devoted to creating flexible designs and furnishings in hospital laboratories. The hypothesis that hospital labs require a high degree of flexibility has been essentially untested. The research methodology involves surveying 2,600 hospital based non-academic clinical laboratories to document the nature and degree of change that has occurred in the last five years. Support for this study was provided by Herman Miller, Inc.

Color in Healthcare Environments: A Critical Review of the Research Literature
Conducted by the University of Missouri, Columbia, the research methodology involves examining color theories applied the healthcare environments, design guidelines for color specification, and organizing the research on color for better access. Support for this study was provided by the AIA Academy of Architecture for Health.

Limiting the Spread of Infection in the Healthcare Environment
The propagation of infection has become a major source of concern to design professionals and hospital facility managers and clinicians. The goal of this study, which is being conducted by Northwestern Memorial Hospital in Chicago, is to evaluate materials typically used in healthcare settings and determine which material(s) provides the best protection against the propagation and transmission of infectious diseases.

The Use of Single Patient Rooms Vs. Multiple Occupancy Rooms in Acute Care Environments
This is a two-phase project. Phase One research work is being conducted by Simon Fraser University in Vancouver, BC. Researchers are empirically documenting and comparatively analyzing the "first costs" of single vs. double residents' rooms in acute healthcare settings. It also includes documenting and comparatively analyzing a sampling of the operational cost differentials between the two room types with particular emphasis on staffing and maintenance costs. This second phase of this project is expected to go into operational cost differentials in more detail. Support for this study was provided by The Facility Guidelines Institute.

Why Join CHER?

Membership in CHER says that your organization supports CHER's goal of developing a national program of health facility related research. It gives you reliable information on which to base your business decisions and provide service to your clients. Members have a voice in setting the research agenda and have early access to our research findings.

Other benefits include an invitation to join in Board and Provider Council deliberations, a semi-annual newsletter, discount on research reports, and the opportunity to exchange ideas and information with colleagues and peers. In addition to the CHER membership list, our newsletter is distributed to approximately 300 individuals who have requested it. This list expands with every issue. Each newsletter identifies all members' organizations.

Who Can Join CHER?
Membership in CHER is open to organizations that share our mission to promote, fund, and disseminate research to help create more humane, effective, and efficient environments through multidisciplinary collaboration dedicated to quality healthcare for all.

There are three categories of membership:

1. Organizational Members
Not-for-profit associations or organizations that represent professional disciplines and have a commitment to or interest in the healthcare facility environment can join with no annual dues as Organizational Members. Representatives participate in setting priorities for research, assist in expanding our membership and help raise funds for research or fund specific research projects.

2. Provider Council
Healthcare providers who have a commitment to or interest in the built environment and expanding the knowledge base of facility-related design and operational issues can join the Provider Council. Representatives are expected to provide advice and counsel on the continually evolving research agenda and to assist in prioritizing that agenda on a yearly basis. There is no cost for becoming a Provider Council member.

Members have a voice in setting the research agenda and have early access to our research findings.

3. Sustaining Members - $2,500 annual dues
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Nature and Rate of Change in Clinical Laboratories

Dina Battisto and David Allison, Architecture + Health, Clemson University

Clinical laboratories in the U.S. are experiencing a tremendous amount of change. Advances in information and automation systems, as well as services and point-of-care testing are influencing laboratory workplaces nationwide.

This 56-page report is a must-read for those who want to know how these changes are affecting the need for flexible building designs and furnishings.

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