The Application of Color in Healthcare Settings

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About the Funders

Jain Malkin Inc.

Jain Malkin Inc. is an interior architecture firm recognized internationally in the field of healthcare design and senior living. The firm has been an advocate for research-based design since Jain Malkin's book *Hospital Interior Architecture* was published in 1992. That book had a chapter on the use of color in healthcare facilities to help guide practitioners in this important component of interior design. "The Application of Color in Healthcare Settings" continues this valuable discussion. www.jainmalkin.com.

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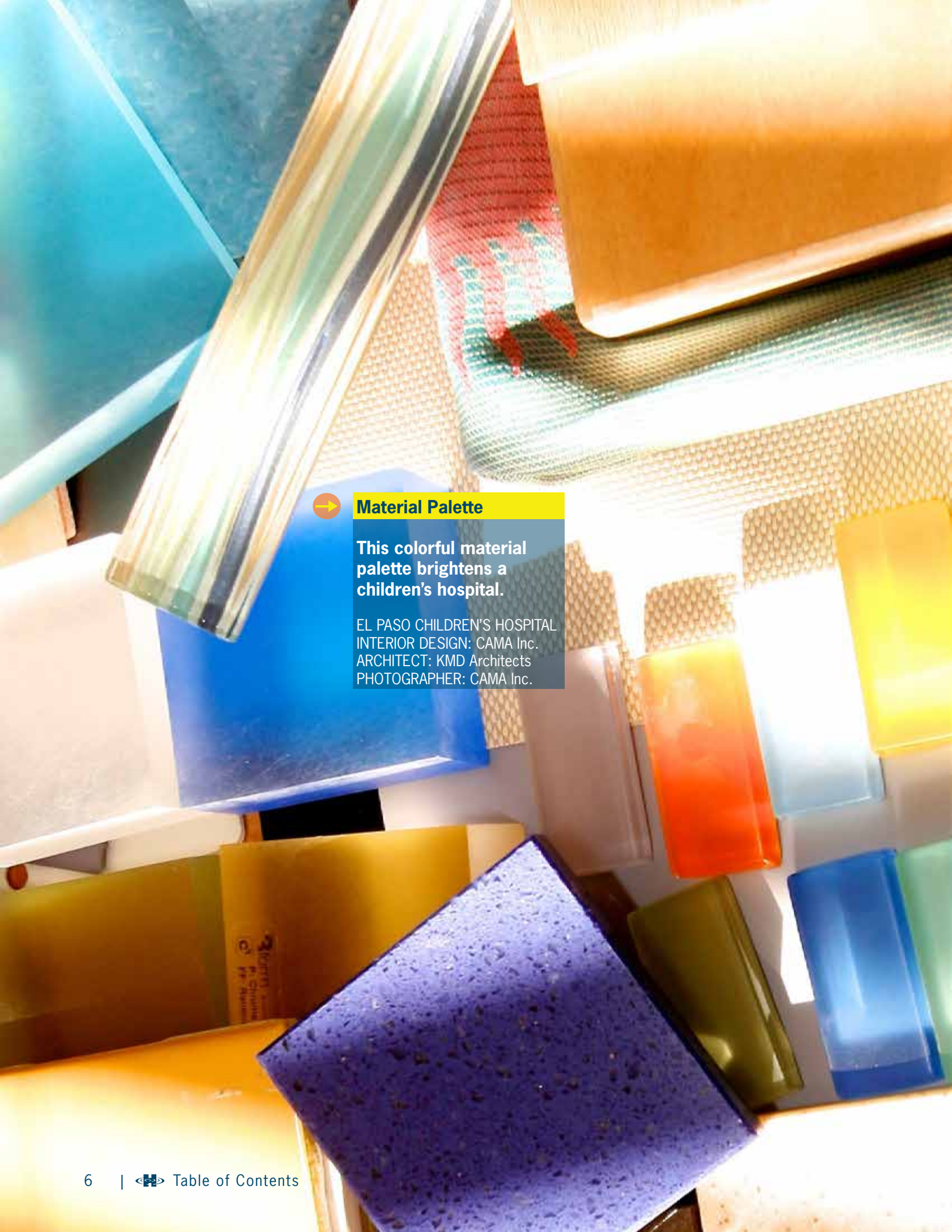
The Center for Health Design

The Center for Health Design (CHD) is a nonprofit organization that engages and supports professionals and organizations in the healthcare, construction, and design industry to improve the quality of healthcare facilities and create new environments for healthy aging. CHD's mission is to transform healthcare environments for a healthier, safer world through design research, education, and advocacy.



Material Palette

This colorful material palette brightens a children's hospital.

EL PASO CHILDREN'S HOSPITAL
INTERIOR DESIGN: CAMA Inc.
ARCHITECT: KMD Architects
PHOTOGRAPHER: CAMA Inc.

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Executive Summary

In the last half of this century, a vast number of books have been written on the topic of color—the psychology of color, color theory, color and the environment, color and light, and color and culture … to name a few. Interestingly, each is filled with individual studies—not necessarily in healthcare—and many suggest definitive conclusions about the best colors for a range of users and settings, or color preferences for boys and girls, different cultures, and so forth.

In today's context of research, however, the methodological rigor of these studies falls short of what we have come to expect with the introduction of evidence-based design. An extensive review of color literature carried out in 2004 by Tofle, Schwarz, Yoon, and Max-Royale concluded that there is insufficient evidence to assert that specific colors can evoke a certain mood, nor is there a link that can be made between specific colors and health outcomes.

Despite this, many studies describe how colors can influence performance and the experience of a space. Color can create the illusion of a higher ceiling or a wider room or facilitate cueing in wayfinding orientation. In the healthcare setting, there are many functional uses of color. As an example, a color separation between the floor and the wall in circulation spaces helps those with aging eyes to distinguish between different planes and reduce mobility issues. Since hospitals are likely to serve an increasing number of aging baby-boomers in coming years, the many functional uses of color related to aging and health are very relevant.

Although rigorous rules for the application of color in healthcare settings will not be found in this paper, there are suggestions for the application of color as well as issues for practitioners to consider such as the type of activity that will occur in a space and whether it requires concentration or social interaction, the age of the occupants, their mobility, the nature and severity of the illness, and the amount of brightness and contrast required to perform tasks safely.

Much of what we think we know about color is anecdotal. The results of many color studies that are often quoted have been done in laboratory settings or using small color chips representing basic primary colors. This is very different than the experience of color on walls in an interior environment. It is difficult to do controlled studies on color in real-world settings and even more challenging in clinical environments.

This paper's value is as a reference for architects and designers as it presents what is currently understood about color, separating research from experience and anecdote, and it is likely to give many design professionals confidence about the application of color to their projects.

The Appendix discusses the cultural implications of color.

Research Highlights

This paper looks at studies of color in a number of different healthcare settings—from pediatric to geriatric nursing units—and considers a variety of uses—from signage to wayfinding. Here are some of the key findings from the literature review of rigorous peer-reviewed studies on color in healthcare settings during the past decade.

Dittmar (2001) found in a large-scale study using color names alone (blue, green, red, yellow) highly significant differences in color preference with advancing age; increased age was correlated with decreased preference for blue. There was no significant gender difference for preferred colors, but a gender difference in least preferred colors.

Park (2009) examined color preferences among pediatric outpatients, inpatients, and healthy children and found no statistically significant difference in color preference among the three groups of children, and, therefore, did not support the hypothesis that pediatric patients would have different color preferences than healthy children. However, all preference comparisons revealed that white was the least preferred color.

Gibson, MacLean, Borrie, and Geiger (2004) examined the behavior of 19 residents in a long-term care dementia unit and found that 13 used color to help them find their rooms, with structure (e.g., room number, name plate) as the second most often reported visual cue.

Blumberg and Devlin (2006) used a demographic questionnaire, a photographic comparison test, and a design questionnaire with 100 junior high school students. Responses to the photographic comparison test showing healthcare settings indicated that adolescents prefer the "bright colors and inventive design" of a child-focused hallway. For a set of lobby images, the majority of the adolescents preferred the adult-oriented photo, possibly because of the tricycle, pastel colors, and toys in the child-oriented lobby that were age-specific and not geared toward adolescents.

Color was one component of the changes made in a corridor of a psychiatric hospital intended to reduce the "institutional" feeling of the space and provide a "sense of nature" in a paper by **Edgerton, Ritchie, and McKechnie (2010).** The renovation did not affect the number of patients using the corridor, but there was an increase in the number of positive behaviors, although the difference was not statistically significant, except for an increase in "talking" behavior.

Rousek and Hallbeck (2011) report that color contrasts can improve signage comprehension and conclude, from a limited set of colors and graphics tested, that a combination of red and white backgrounds with black font was preferred. It should be noted that the font, size, scale, and color contrast are very important, along with the intelligibility of the design graphic itself.

Beyond Vanilla

White walls are often associated with a clinical appearance and institutional settings. Adding color and an interesting ceiling design, as in this procedure room, can make the environment seem less intimidating.

SCRIPPS CENTER FOR INTEGRATIVE MEDICINE
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Schmidt Scanlon Gordon
PHOTOGRAPHER: Michael Campos

Introduction

There are few design topics more interesting than the use of color in our daily lives. We are surrounded by an ever-changing palette of color in nature that inspires the principles used in the creation and selection of materials for interior design. These same principles also apply in the culinary presentation of food and the creation of fine art. Since color is an inseparable part of our lives, it is all the more puzzling to explain the lack of it in many of our new hospitals.

Thus, the origin of this paper is based on this very observation: A number of new hospitals built in the last five years have been lacking in color. We wondered what forces are at work here? Clearly it is more difficult, and more risky, to successfully apply color to an interior environment than to use a neutral palette, but there are likely a number of factors in play here.

The importance of this issue, however, goes beyond aesthetics. Is it possible to enhance the patient's experience and potentially impact clinical outcomes by understanding how to apply color in healthcare settings? The environment may be even more important in the acute-care setting. Recent neuroscientific research and studies of circadian rhythms demonstrate that the color spectrum of light directly influences human biological systems and health outcomes (Edelstein, 2008). Topics such as lighting, biophilic design, color theory and application, color and the aging eye, the cultural dimension of color, and physiological and psychological responses to color all demand attention when thoughtfully designing and shaping the interior environment.

This paper will concentrate on the application of color in healthcare settings.

Color and Brand

Color may be tied to an institution's logo or corporate brand.

YALE-NEW HAVEN HOSPITAL
INTERIOR DESIGN: CAMA Inc.
ARCHITECT: Salvatore Associates
PHOTOGRAPHER: Rick Scanlan

Role of Color in Healthcare Environments

Current State of Research on Color

Many color guidelines have been proposed for healthcare settings, but these only offer hypotheses suggesting that certain colors may be associated with the well-being of the users of those spaces. Tofle, Schwarz, Yoon, and Max-Royale (2004) conducted an extensive literature review and analysis of several color guidelines and noted that there are considerable contradictions among guidelines and in the literature on color.

Tofle et al. (2004) state that the art of specifying certain colors to evoke a particular mood or influence behavior is unsubstantiated by research evidence. Although some studies have demonstrated that color-mood associations do exist, they could not conclude that there is a one-to-one relationship between a certain color and a specific emotion. We note for example, that while some designers use white to evoke a sense of clarity and denote cleanliness, others state that white walls are clinical and even eerie.

Edelstein and colleagues also conducted an extensive search of peer-reviewed literature on the influence of light and color on behavior, emotion, function, cognition, circadian rhythms, and health (Edelstein, 2006; Edelstein, 2008; Edelstein, et al., 2008). They found the greatest consistency in color studies focused on the brightness and color contrast, consistent with knowledge from the visual sciences and clinical research. Such research can be applied to manipulate perceptual impressions, such as a sense of spaciousness. Together these literature reviews conclude there was insufficient evidence to directly link specific colors with specific behavioral or health outcomes.

The authors conducted a broad search of color literature published, using search terms focused on color in healthcare settings. The search included journals spanning design, architectural, sociological, psychological, physiological, and nursing and medical disciplines. Studies cited in the National Library of Medicine's PubMed Medline and the Web of Knowledge databases provided a rich source of information, yielding thousands of articles that investigated the human response to light and color.

Art as a Color Scheme Component

Art creates an analogous color scheme in this hospital setting.

DUBLIN METHODIST HOSPITAL
INTERIOR DESIGN: Karlsberger and CAMA Inc.
ARCHITECT: Karlsberger
PHOTOGRAPHER: Brad Feinknoph

The publications meeting our criteria for peer-reviewed empirical studies of color in healthcare settings are reported below.

Color and Healing

It has been suggested that color has a therapeutic effect, although few empirical observations exist. Edelstein et al. (2008) reviewed citations from biomedical literature and found that while influence of the colored light on health was supported by several decades of rigorous research into circadian rhythms, there was a paucity of consistent data on the influence of applied color on health.

Tofle et al. (2004) note that "oversimplification of the psychological responses to color pervades the popular press, and direct applicability to architecture and interior design of healthcare settings seems, "oddly inconclusive and nonspecific" (p. 5). They assert, "The attempt to formulate universal guidelines for appropriate colors in healthcare settings is ill advised (p. 5)."

Schuschke and Christiansen (1994) also found that "no compelling scientific reasons can be given for coloration in the hospital." For example, their study of 68 patients found heterogeneity in their choice of sick-room color in clinics and could not support specific or absolute color solutions. Nonetheless, in all 68 subjects, a preference for light colors for all objects such as ceiling, wall, floor, curtain, furniture, and linen were reported.

Color Preference Associated With Aging

The effect of aging on color perception and preference should be considered in addition to the influence of visual dysfunctions and disorders often associated with advancing years. The natural aging and yellowing of the lens alters not only the optics but also the perception of color and response to glare and darkness through which the environment is perceived. Using four color cards, Mather, Stare, and Brenin (1971) found the color preference order in geriatric patients was blue, red/green, then yellow—consistent with other widely reported results of "blue preference." Wijk, Berg, Sivik, and Steen (1999), using a color naming test of seven colors with 80-year-olds, found preference order was consistent with earlier studies and remained stable with age.

Relationships of Color

To visualize the relationship of colors, imagine a sphere with the familiar “flat” color wheel at the equator and the color white as the North Pole and black as the South Pole. At the equator, the colors are highly saturated and vibrant. As white is added incrementally, moving toward the top of the sphere, colors become pastel tints. As you move toward the bottom of the sphere, or South Pole, black is added in even increments and colors become dark and are sometimes referred to as shades. The core of the sphere moves through a gray scale from black to white. The sphere can be sliced at any point above or below the equator revealing a color wheel in which each of the colors (hues) is the same value of lightness or darkness. (Adapted from Philipp Otto Runge, the originator of the color sphere, 1810.)

Newton’s Color Wheel

Imagine a time when colors had no names. Sir Isaac Newton, in the 17th century, using a glass prism, divided sunlight into the colors of the daylight spectrum. He then arrayed the colors around a circular ring with white in the center and blue opposite orange. Newton’s color wheel of six colors, however, is very different from today’s version. This work was the starting point for investigation of complementary colors in the latter part of the 18th century (Gage, 1999).

Color and the Aging Eye

Rousing, bright colors are more appropriate in environments for the aged than pastels, which are barely visible to those with failing eyesight.

SEACREST VILLAGE RETIREMENT COMMUNITY - SAN DIEGO HEBREW HOMES
INTERIOR DESIGN: Jain Malkin Inc.
PHOTOGRAPHER: Steve McClelland

Art Corridor

Whimsical corridor uses bright colors effectively against a neutral palette for major surfaces.

RANDALL CHILDREN'S HOSPITAL AT LEGACY EMANUEL
INTERIOR DESIGN: ZGF Architects LLP
ARCHITECT: ZGF Architects LLP
PHOTOGRAPHER: Craig Collins ©Hendrich Blessing

Gift Shop

Emphasis on the ceiling with playful graphics and lighting carry the eye through the shop to the rear wall. This is likely to draw visitors into the depth of the space, which means more potential purchases.

RANDALL CHILDREN'S HOSPITAL AT LEGACY EMANUEL
INTERIOR DESIGN: ZGF Architects LLP
ARCHITECT: ZGF Architects LLP
PHOTOGRAPHER: Nick Merrick ©Hendrich Blessing

Cool and Calm

Blue color is calming in a high-stress setting.

RANDALL CHILDREN'S HOSPITAL AT LEGACY EMANUEL
INTERIOR DESIGN: ZGF Architects LLP
ARCHITECT: ZGF Architects LLP
PHOTOGRAPHER: Nick Merrick
©Hendrich Blessing

Color Accents

Dramatic ceiling design and lighting are complemented by bright accents of color.

RANDALL CHILDREN'S HOSPITAL AT LEGACY EMANUEL
INTERIOR DESIGN: ZGF Architects LLP
ARCHITECT: ZGF Architects LLP
PHOTOGRAPHER: Nick Merrick ©Hendrich Blessing

Analogous Color Scheme

Analogous scheme: With the exception of the ceiling, white is absent.

BAYSTATE CHILDREN'S HOSPITAL
INTERIOR DESIGN: CAMA Inc.
PHOTOGRAPHER: Rick Scanlan

However, this conclusion is inconsistent with a more recent large-scale study by Dittmar (2001) (n = 842), who found highly significant differences in color preference with advancing age. While the "blue preference" noted previously was observed, age was correlated with decreasing preference for blue and increasing choice of red/green. In both younger and older adults, there was no significant gender differences for preferred colors, but there was a gender difference for least preferred colors. These changes are opposite to the trend often reported in earlier studies of adults and children.

Children's Preference in Healthcare Environments

Three studies addressed children's preference of color in healthcare environments. Park (2009) examined color preferences among pediatric outpatients, pediatric inpatients, and healthy children (n = 153, aged 7-11) using the Munsell color system for five hues—red (5R 7/8), yellow (5Y 9/8), green (5G 7/8), blue (5B 6/8), and purple (5P 7/8). These colors were selected in their pilot study (n = 63) in which nine brightness/saturation combinations for each hue (45 in all) were tested to identify children's most favorite and least favorite colors. White was also included because its prevalence in healthcare environments.

Ten models (1:12 scale) were built in which everything was the same, with the exception of one interchangeable sidewall where the different colors were displayed. Illuminance levels inside the models was 520 lux for overall illuminance (both incandescent and fluorescent) and 240 lux with the fluorescent light only. For the main study, children saw one model, but with different colored walls sequentially. Color preferences were measured using a modified version of the Pediatric Quality of Life Inventory (PedsQL) by Varni, Seid, and Rode (1999).

There was not a statistically significant difference in color preference among the three groups of children, and, therefore, the study did not support the hypothesis that pediatric patients would have different color preferences than healthy children. It should be noted that all graphs included in Park's paper showed white to be the least preferred color. The authors noted lower preference scores for yellow in patients compared with healthy counterparts (no statistical significance reported). Gender differences for color preference were observed, with males reporting significantly

Complementary Color Harmony

Playful soffit and design combines both warm and cool colors with dynamic shapes. Teal and red are complementary colors that lie opposite one another on the color wheel, accenting a warm neutral wall.

ADELANTE HEALTHCARE
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Cawley
PHOTOGRAPHER: Dustin Revella

lower preferences ($p < .05$) for red and purple when compared to females. Park notes that for a color study to be successful, many confounding variables must be controlled (age, gender, emotion, hue, brightness, saturation, light sources, adjacent colors, contexts, and cultural factors).

Coad and Coad (2008) studied children's preferences for thematic design and color in one acute-care hospital in the U.K. In Phase I ($n = 40$), the study interviewed 30 children and young people who were or had been inpatients, and 10 with additional learning needs and physical disabilities who had accessed services. In Phase II ($n = 140$), a questionnaire was used based upon the Phase I pilot study findings. Analysis was grouped by children aged 11 and younger (range 3 to 11 years) and children aged 12 and older (range 12–18 years). The authors did not analyze statistical probabilities.

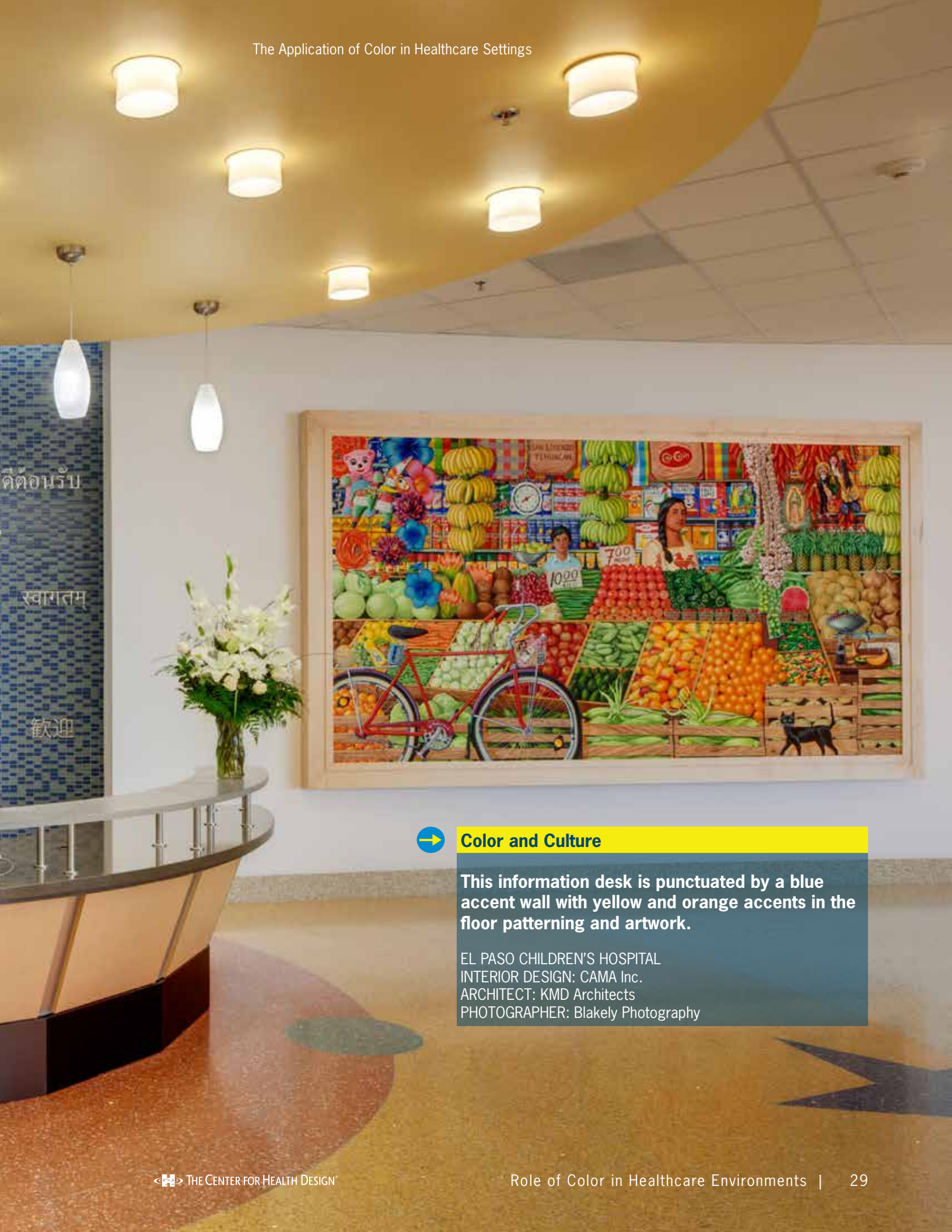
Using descriptive analysis they observed the following trends. In Phase I, participants were asked to select their color preferences for different areas of the hospital from a thematic design chart and leaflet that included over 100 colors. Each of the colors had been preassigned to a color group (reds, greens, yellow, etc.) and scored using a scale of 1 to 9, with 1 representing the most pale and a 9 representing the most dark. Contrary to suggestions, children did not prefer bright colors, but rather pale to midcolor ranges. The most preferred colors were mid blue-green colors. Overall, all of the colors chosen were not bright, as previously suggested (Redshaw & Smithell, 2000).

When asked about their preference for colors in the corridors, most children felt that they should be painted in "warm, inviting colors" and that the corridors should be a single color. The most preferred colors for corridors were "warm blue, pastel green, pale or mid-yellow (not lemon) or mid-oranges." For the nursing areas, responses were almost evenly split between a preference for a single color versus multiple colors.

Single color preferences included "blue accent and pastel yellow and pastel orange." Color combinations most often selected were "shades of blue, orange, pink, neutral and yellows." For playrooms or "chill-out rooms," respondents selected similar colors to those selected for the nursing unit.

Limitations to this study include the use of small color chips that are less

Vítáme tě
Hoş geldin
ยินดีต้อนรับ
AKU'WAM
Dobrodošli
Willkommen
Benvenuto
Добро пожаловать
INFORMATION
Bienvenue
Καλωσόρισμα
Chào Mừng
Bienvenido
خوش آمدید
DELL



Color and Culture

This information desk is punctuated by a blue accent wall with yellow and orange accents in the floor patterning and artwork.

EL PASO CHILDREN'S HOSPITAL
INTERIOR DESIGN: CAMA Inc.
ARCHITECT: KMD Architects
PHOTOGRAPHER: Blakely Photography

Children's Color Preferences

The cafeteria's below-grade dining space calls upon the colors of high-desert flowers to create a dynamic destination. This is an example of a split complementary color scheme.

EL PASO CHILDREN'S HOSPITAL
INTERIOR DESIGN: CAMA Inc.
ARCHITECT: KMD Architects
PHOTOGRAPHER: Blakely Photography

Color Harmony

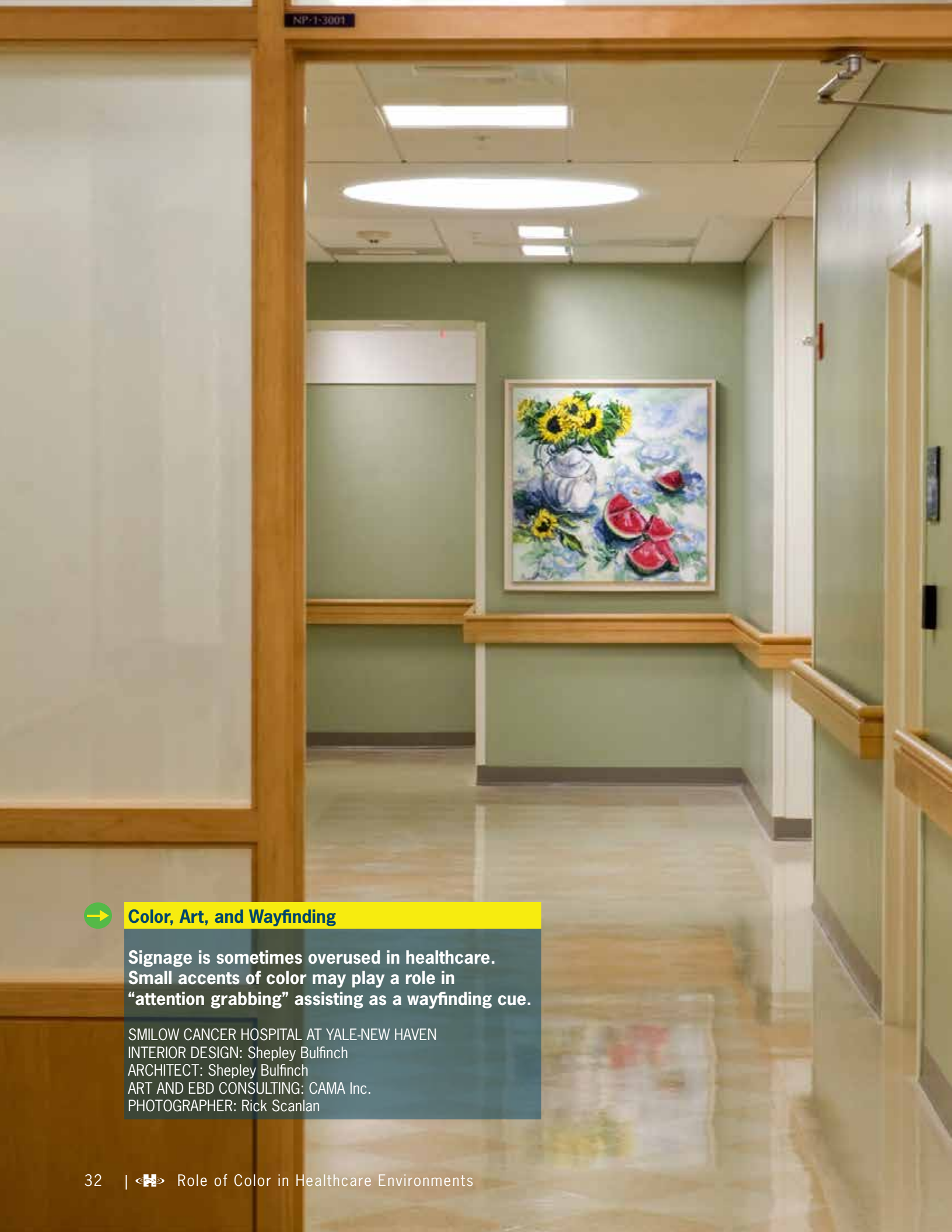
The French chemist Michel Eugène Chevreul, director of the dyeworks for the well–known Gobelin tapestry company in France, wrote one of the most significant books on color harmony (1855). In fact he was the first to define color harmony in a way that would be familiar today: harmonies of complementary colors, split-complements, triad, analogous colors, and tetrad.

Visual Illusion

The artist Josef Albers is a significant figure in contemporary times. His book *Interaction of Color* (2006) examines the changing nature of color based upon the relativity of one color juxtaposed with another. The book has many color plates that demonstrate how easily the eye can be deceived in thinking that a color is lighter or darker, or somehow different, depending on other colors adjacent to it. And he provides numerous examples of vibrating and vanishing boundaries through the use of shape and the selection of hue.

The Purkinje Effect

The Purkinje effect was named after its discoverer, a Czechoslovakian physician, who observed that at twilight, color impressions were shifted to favor the short-wavelength area of the spectrum. Thus, reds, oranges, and yellows become colorless and darker, greens, and blues become clearer (Malkin, 2002). Recommended source: *Theory and Practice of Color* by Frans Gerritsen (1975).



Color, Art, and Wayfinding

Signage is sometimes overused in healthcare. Small accents of color may play a role in "attention grabbing" assisting as a wayfinding cue.

SMILOW CANCER HOSPITAL AT YALE-NEW HAVEN
INTERIOR DESIGN: Shepley Bulfinch
ARCHITECT: Shepley Bulfinch
ART AND EBD CONSULTING: CAMA Inc.
PHOTOGRAPHER: Rick Scanlan

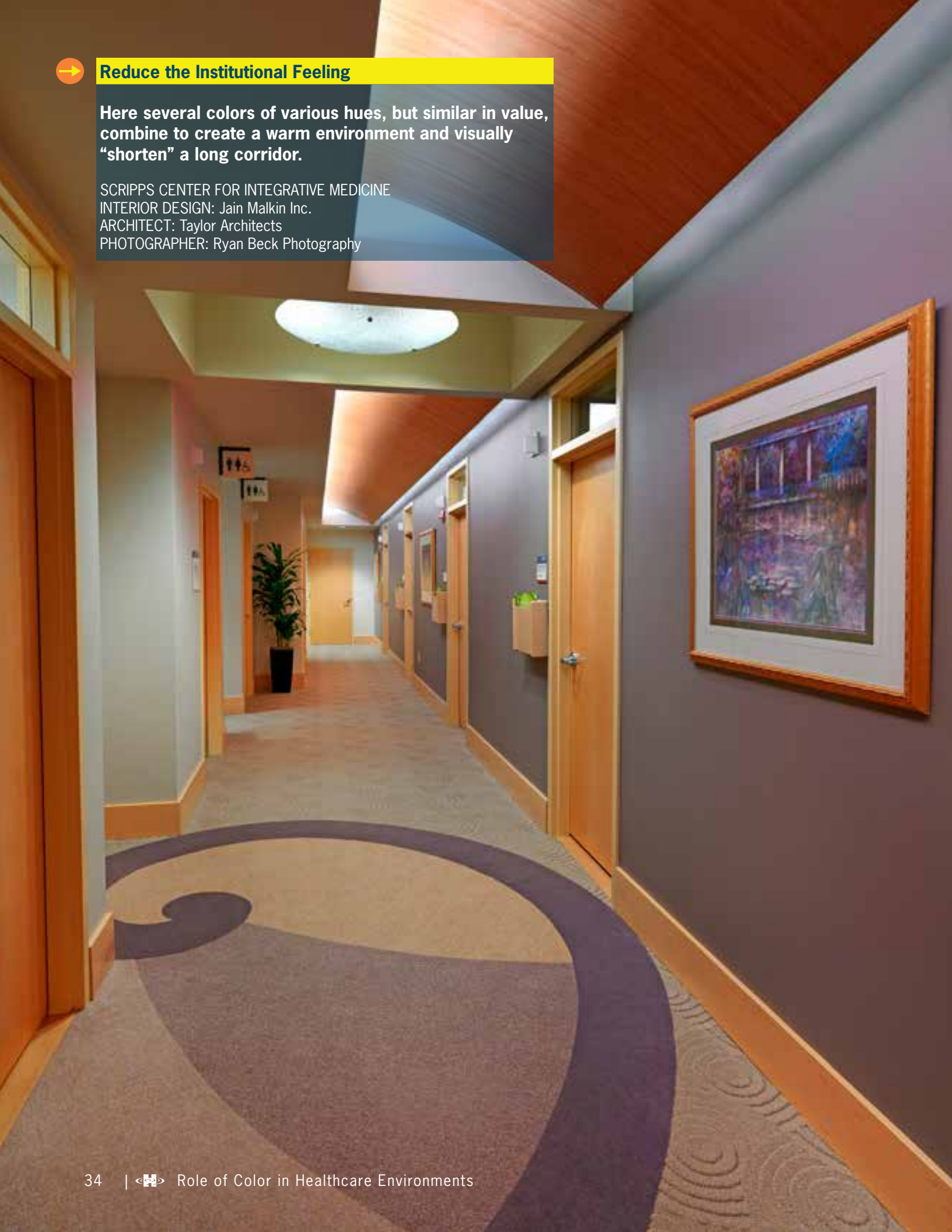
"ecologically relevant" than studies in full-scale painted rooms. The authors noted, "It could be that the design choices are reflections of their environments at home and/or exposure to media such as television programs (the plethora of do-it-yourself and home improvement programs). Several participants referred to wanting the ability to control their environment, such as changing the color of walls and lighting" (Coad & Coad, 2008, p. 44).

Adolescent's Preference in Healthcare Environments

Blumberg and Devlin (2006) administered a demographic questionnaire, a photographic comparison test, and a design questionnaire to 100 junior high school students who had been hospitalized one night or less (aged 12 to 14, 97% European American, majority middle- to upper-middle class) to better understand their preferences regarding the physical design of hospitals. The authors did not report statistically significant probabilities. Although there "were very few significant differences between the responses of those who had been hospitalized overnight and those without such hospitalization experience, findings from this study are still based largely on preferences for imagined circumstances. Unless an individual has actually experienced hospitalization, predictions of behavior may be inaccurate" (Blumberg & Devlin, 2006, p. 314). In addition, the authors suggest extending such studies to include adolescents up to 18-years-old and an improved study design with fewer overlapping confounding factors.

In their photographic comparison task, students were shown four different color prints from hospitals, two of hallways and two of lobbies, with one of each representing a more adult-oriented design and the other a child-oriented design. Students were asked to write down three things they liked and three things they disliked about each of the photos and were allowed to add other comments as well. The design questionnaire included questions pertaining to seven different topics, including several questions regarding a hypothetical stay at a hospital.

Responses to the picture comparison task frequently mentioned color and design, with 50% of respondents mentioning the color palette in the adult-oriented hallway and 73% commenting about colors in the child-oriented hallway. The adult-oriented hallway included "subtle colors" and the childlike hallway used a "brighter array of colors." Of the students who indicated a preference for one of the hallway images,



Reduce the Institutional Feeling

Here several colors of various hues, but similar in value, combine to create a warm environment and visually "shorten" a long corridor.

SCRIPPS CENTER FOR INTEGRATIVE MEDICINE
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Taylor Architects
PHOTOGRAPHER: Ryan Beck Photography

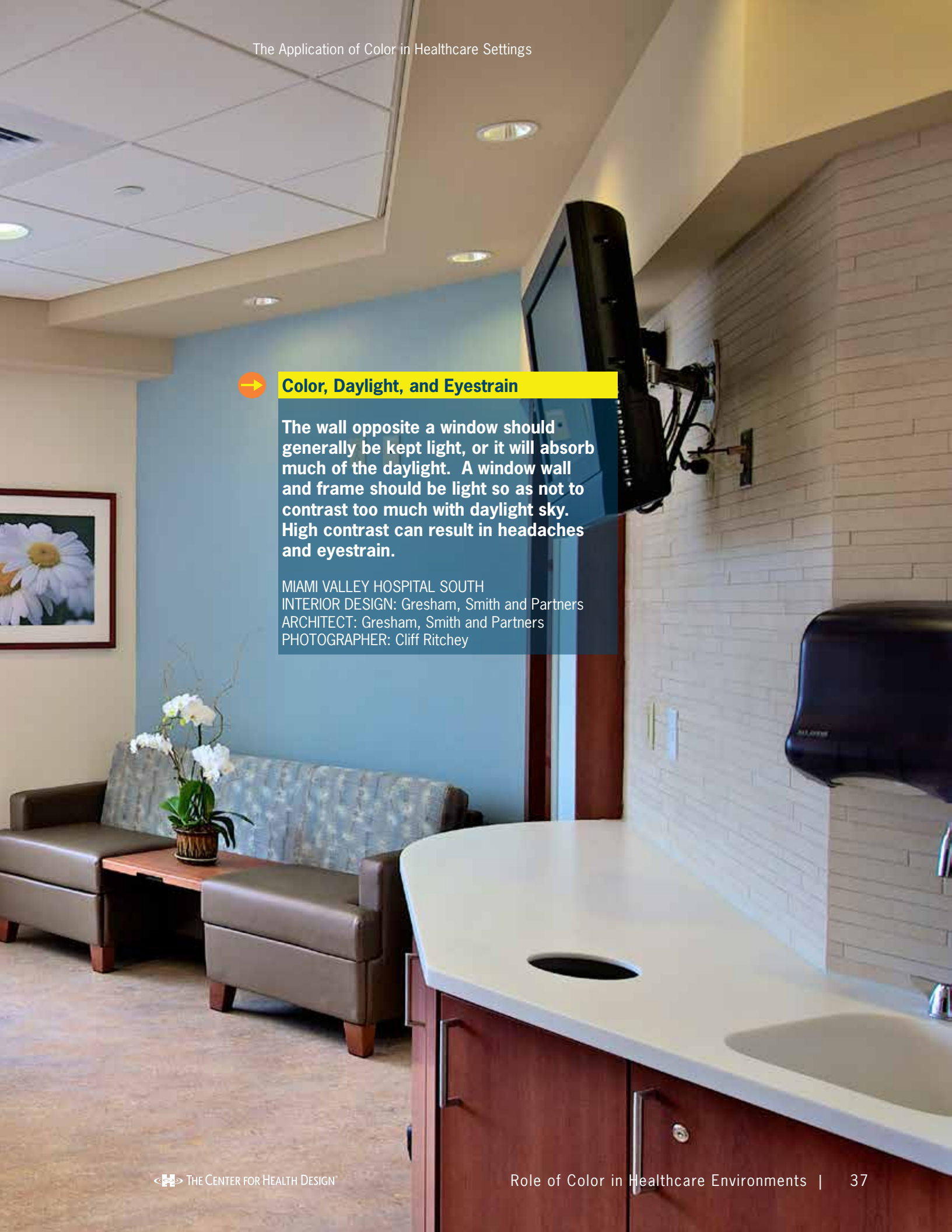
26% preferred the adult hallway and 54% preferred the child-oriented hallway, indicating that adolescents prefer the "bright colors and inventive design" of the child-focused hallway. For the set of lobby images, the majority of the adolescents preferred the adult-oriented photo, possibly because of the tricycle, pastel colors, and toys in the child-oriented lobby that were age-specific and not geared toward adolescents.

Color in Psychiatric Settings

Color was one component of the changes made in a corridor of a psychiatric hospital intended to reduce the "institutional" feeling of the space and provide a "sense of nature" in a paper by Edgerton, Ritchie, and McKechnie (2010). Descriptive statistics were presented, Chi-square analysis was conducted to compare patient behavior in the corridor pre/post redesign, and independent *t* tests were conducted to compare patient and staff perceptions of the corridor before and after design changes.

The floor, ceiling, and walls were changed to colors that commonly occur in nature—primarily blues and greens. Other changes included replacing transparent glass with opaque glass to obstruct unattractive views while letting in daylight, removing "institutional-style" panels from the walls, and installing two paintings and other modifications to improve the appearance of the corridor. Using behavior mapping, researchers recorded whether or not behaviors of people in the corridors involved social interaction and whether the behaviors were "positive" (e.g., getting coffee, talking) or "negative" (e.g., staring into space or talking to oneself).

The renovation did not affect the number of patients using the corridor, but there was an increase in the number of positive behaviors, although the difference was not statistically significant, except for an increase in "talking" behavior. Significant differences (p value not specified) were claimed suggesting that patients found the renovated corridor to be "cleaner, quieter, and more likely to make them feel good." However, the staff was significantly more likely to rate the redesigned corridor as less bright and airy compared with the corridor before it was redesigned (p value not specified).



Color, Daylight, and Eyestrain

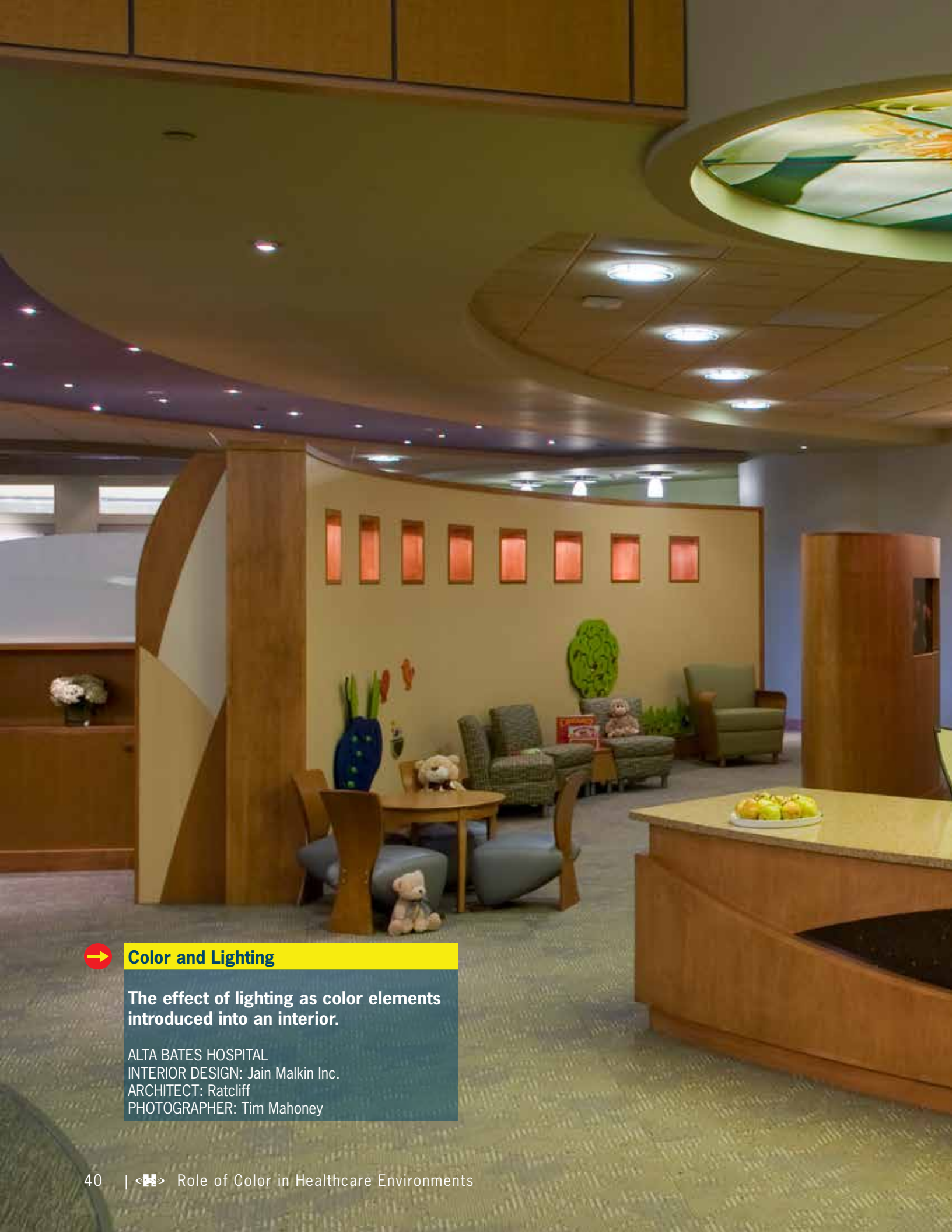
The wall opposite a window should generally be kept light, or it will absorb much of the daylight. A window wall and frame should be light so as not to contrast too much with daylight sky. High contrast can result in headaches and eyestrain.

MIAMI VALLEY HOSPITAL SOUTH
INTERIOR DESIGN: Gresham, Smith and Partners
ARCHITECT: Gresham, Smith and Partners
PHOTOGRAPHER: Cliff Ritchey

Colors That Calm

Patient rooms feature colors intended to calm patients and their family members.

MIDDLE TENNESSEE MEDICAL CENTER
INTERIOR DESIGN: Gresham, Smith and Partners
ARCHITECT: Gresham, Smith and Partners
PHOTOGRAPHER: Aerial Innovations



Color and Lighting

The effect of lighting as color elements introduced into an interior.

ALTA BATES HOSPITAL
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Ratcliff
PHOTOGRAPHER: Tim Mahoney

Color and Wayfinding

Here color is used to define department entrances and aid in wayfinding.

UNIVERSITY MEDICAL CENTER OF PRINCETON AT PLAINSBORO
INTERIOR DESIGN: HOK and Hillier/RMJM
ARCHITECT: HOK and Hillier/RMJM
EBD CONSULTING: CAMA Inc.
PHOTOGRAPHER: Richard Titus

Color for Signage in Healthcare Settings

For many years, color has been used to inform wayfinding. Gibson, MacLean, Borrie, and Geiger (2004) examined the behavior of 19 (all male; mean age of 84.3 (*SD* = 4.1) residents in a long-term care dementia unit following the renovation of the unit. The renovation was intended to make the unit feel less "institutional" and create an entrance to each room that was more visibly distinct, using "color, texture and cosmetic architectural structure." Patients who were able to find their way to their rooms were interviewed using five free-response questions that allowed residents to share information regarding environmental cues that assisted them in this task. Residents who could not successfully find their room were not interviewed.

Thirteen of the 19 participants reported that color was used to help them find their rooms. Structure (e.g., room number, name plate) was the second most often reported cue (12 of 19 participants). Generalization of results from this study are limited by its small sample size, narrow age range, and the medical condition of participants.

The use of color and graphic images may be vital factors in healthcare design. As hospitals have a wide range of visitors and patients with different levels of visual impairments and disabilities, making comprehensible signage is essential. In the United States, color coding has been developed to reduce confusion and aid in decision making by specifying color stereotypes: warning information in red, caution information in yellow or amber, and advisory information in another color clearly discriminable from red or yellow/amber.

ANSI and the ISO have introduced similar universal color-coding standards (ISO 3864-1) and include green for safety. These ISO standards for safety colors, signs, and graphics are specifically designed to reduce accidents and injuries in public facilities, such as hospitals, worldwide. However, color in signage must be used with caution. For example, red-green color blindness and red-blue combinations can be difficult to resolve and have been shown to cause eyestrain thought to be due to the different focusing levels required as these colors are on the opposite end of the visible spectrum of the human eye.

The Americans With Disabilities Act reviews signage guidelines, recommending that the finish and contrast of the characters and background of signs be eggshell, matte, or other nonglare finish, and that characters and symbols contrast with their background by 70%.

Color and Wayfinding

Color and imagery reinforce the identity of exam suites; a patient advisory group participated in this design decision in order to empower visitors to navigate the facility more independently.

MEDICAL COLLEGE OF GEORGIA
INTERIOR DESIGN: CAMA Inc
ARCHITECT: HEERY
PHOTOGRAPHER: Dave Dawson

Rousek and Hallbeck (2011) report that with normal vision, 38% of participants had trouble recognizing signage during a wayfinding task; most commonly small lettering (18%), insufficient illumination (18%), insufficient contrast between the background and letters (10%), and mounting signage too high (8%). Studies simulating visual impairment by having subjects wear goggles showed many participants (70%) in their wayfinding study had trouble recognizing signage. The most commonly reported issues were improper illumination (38%), unexpected positioning (36%), and failing to notice the signage (14%). Sixty of the participants felt the signs were too small.

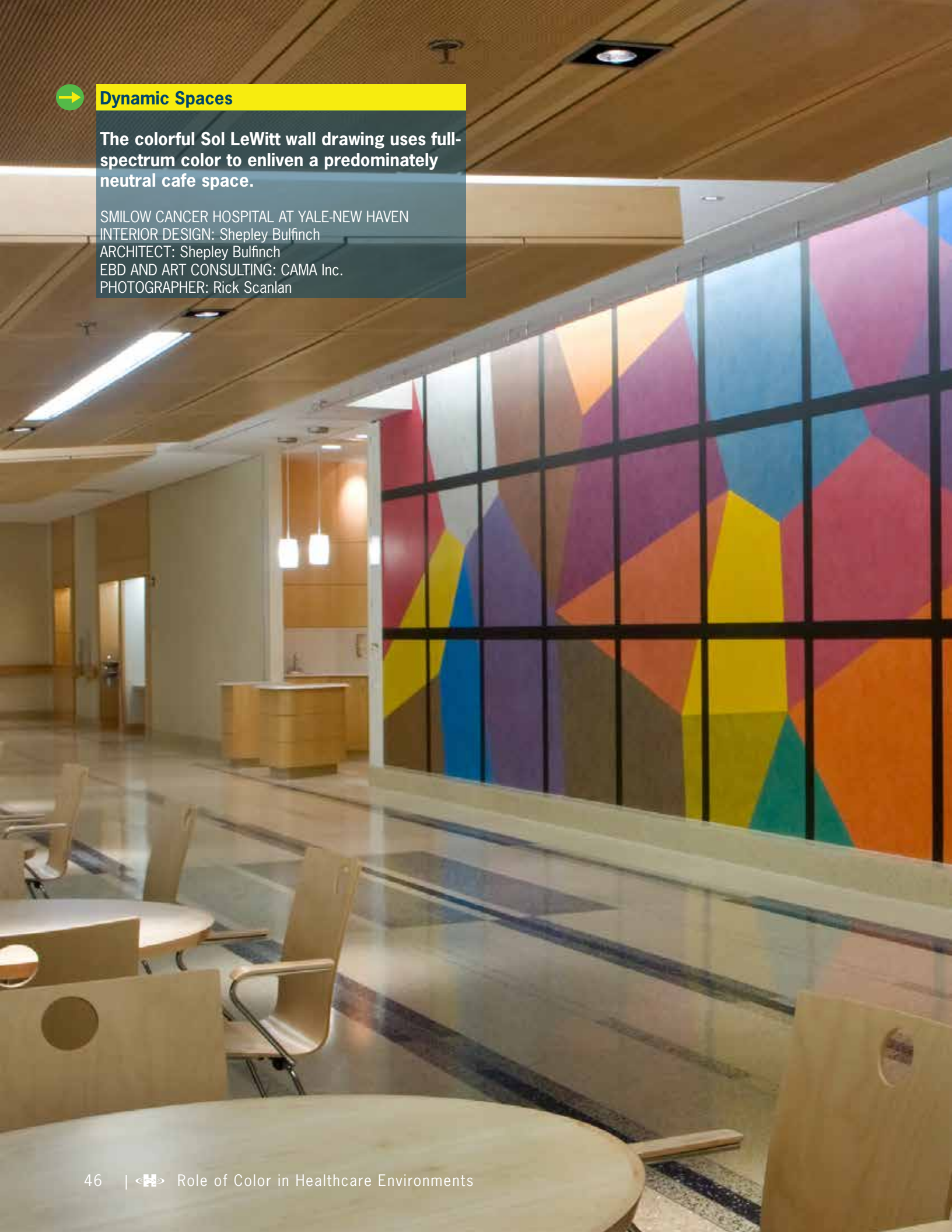
They studied the use of signage color in the healthcare setting. Participants (n = 50) with healthy eyes were asked to respond to various pictograms (some with color and some black and white only) using three questionnaires, both with and without goggles designed to simulate 5 types of visual impairments (diabetic retinopathy, glaucoma, cataracts, macular degeneration, or hemianopsia).

The researchers found that color contrast improved signage comprehension and concluded from the limited set of colors and graphics tested (black, blue, white, red, green), that a combination of red and white backgrounds with black font was preferred. It should be noted that the font, size, scale, and color contrast are very important, along with the intelligibility of the design graphic itself.

Discussion

While there are few color studies that have been conducted specifically for healthcare settings, it is appropriate to consider findings from studies in all built settings used by people. Indeed, hospitals include all architectural types such as bedrooms and residential spaces; places to heal, to sleep, to work; and to support the business of healthcare. Thus, a broader literature review that includes all architectural spaces, though outside the scope of this review, is warranted.

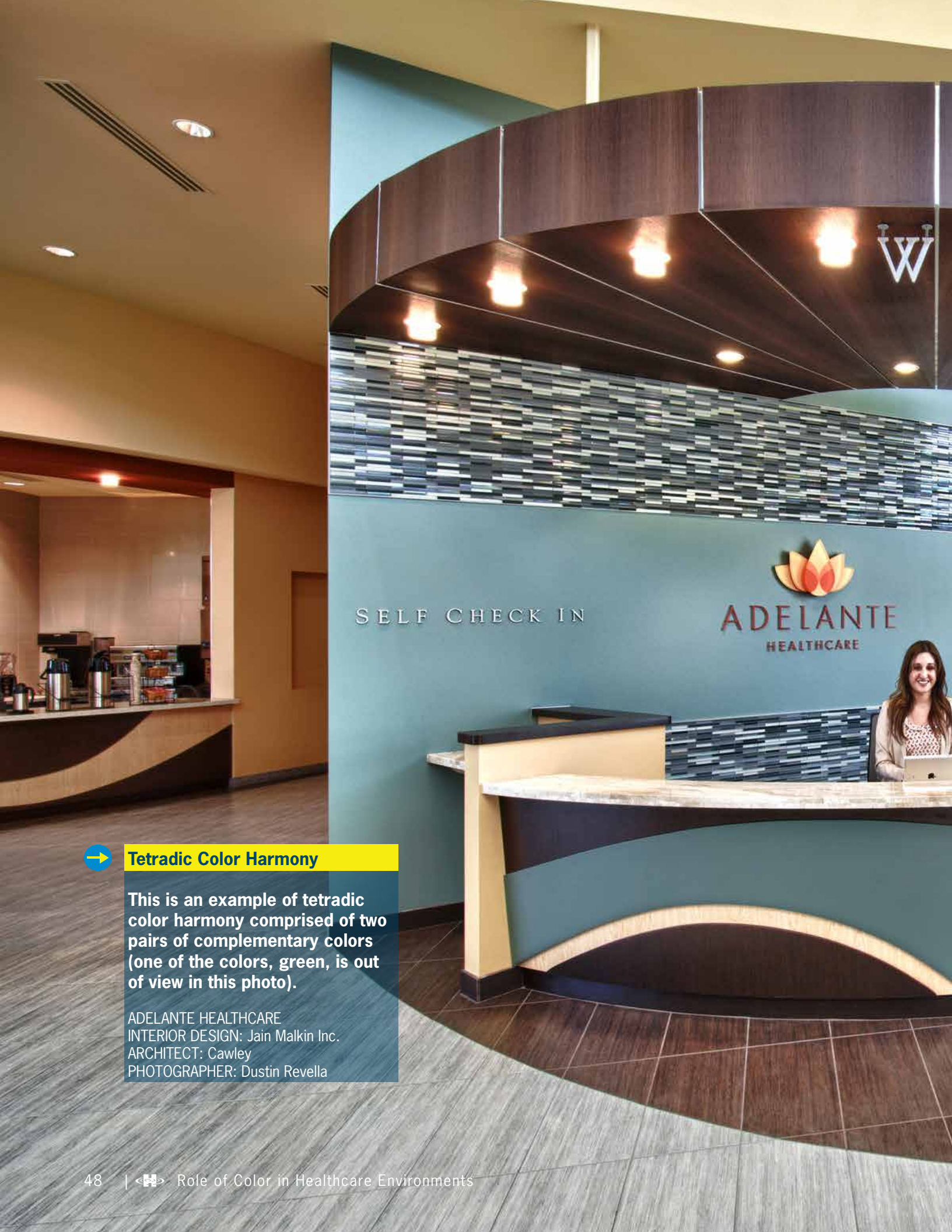
A great wealth of information is available from biological, psychological, sociological, and anthropological literature about color that far exceeds this review. However, a critical eye must be cast on earlier studies, some of which are still quoted despite being laden with societal biases and preconceptions (Edelstein et al., 2008). Meta-analyses of this literature should discriminate rigorous empirical studies from those



Dynamic Spaces

The colorful Sol LeWitt wall drawing uses full-spectrum color to enliven a predominately neutral cafe space.

SMILOW CANCER HOSPITAL AT YALE-NEW HAVEN
INTERIOR DESIGN: Shepley Bulfinch
ARCHITECT: Shepley Bulfinch
EBD AND ART CONSULTING: CAMA Inc.
PHOTOGRAPHER: Rick Scanlan

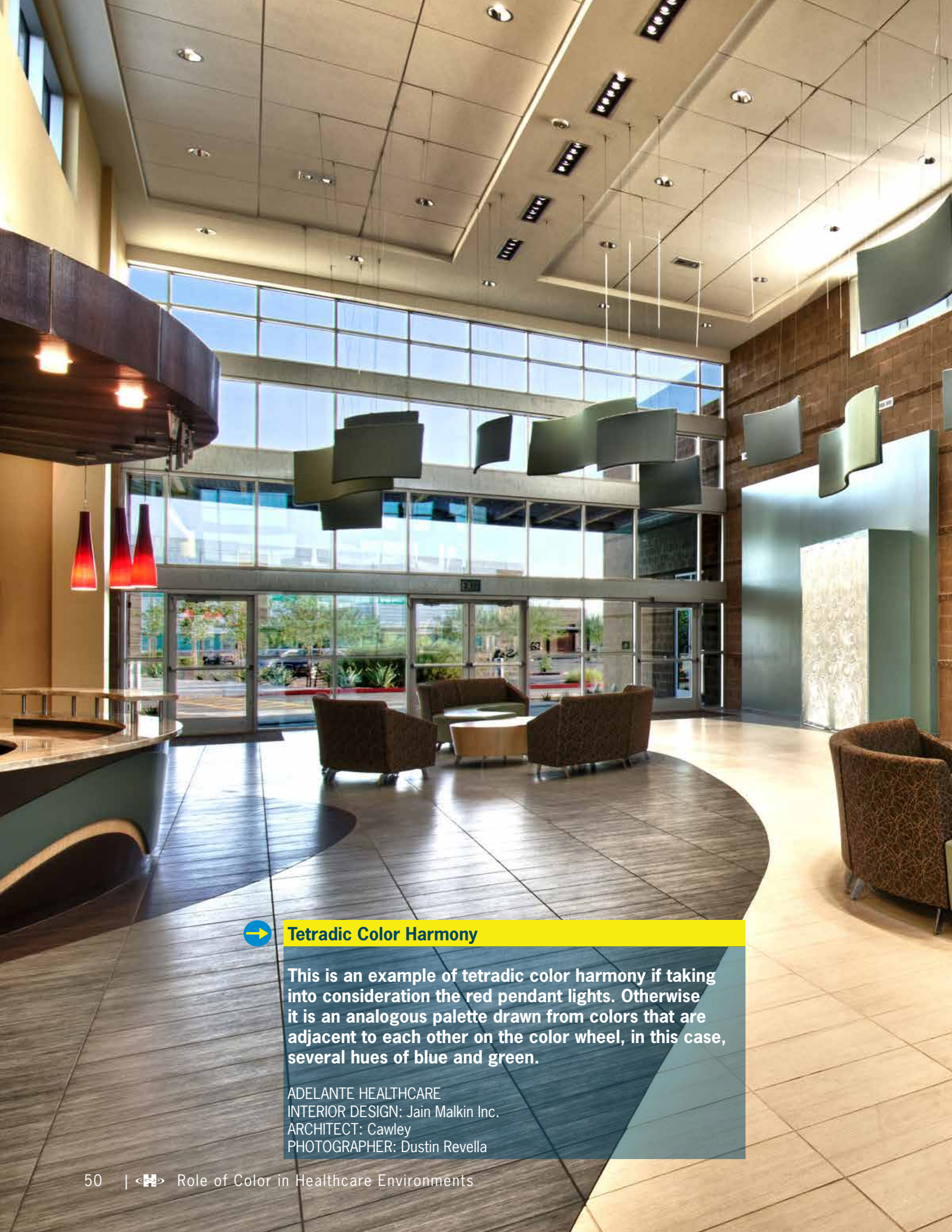


Tetradic Color Harmony

This is an example of tetradic color harmony comprised of two pairs of complementary colors (one of the colors, green, is out of view in this photo).

ADELANTE HEALTHCARE
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Cawley
PHOTOGRAPHER: Dustin Revella

ELCOME
SELF CHECK IN



Tetradic Color Harmony

This is an example of tetradic color harmony if taking into consideration the red pendant lights. Otherwise it is an analogous palette drawn from colors that are adjacent to each other on the color wheel, in this case, several hues of blue and green.

ADELANTE HEALTHCARE
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Cawley
PHOTOGRAPHER: Dustin Revella

Dynamic Spaces

Bright, strong colors stimulate and encourage activity.

ELEMENTARY INSTITUTE OF SCIENCE
INTERIOR DESIGN: Jain Malkin Inc.
PHOTOGRAPHER: Steve McClelland

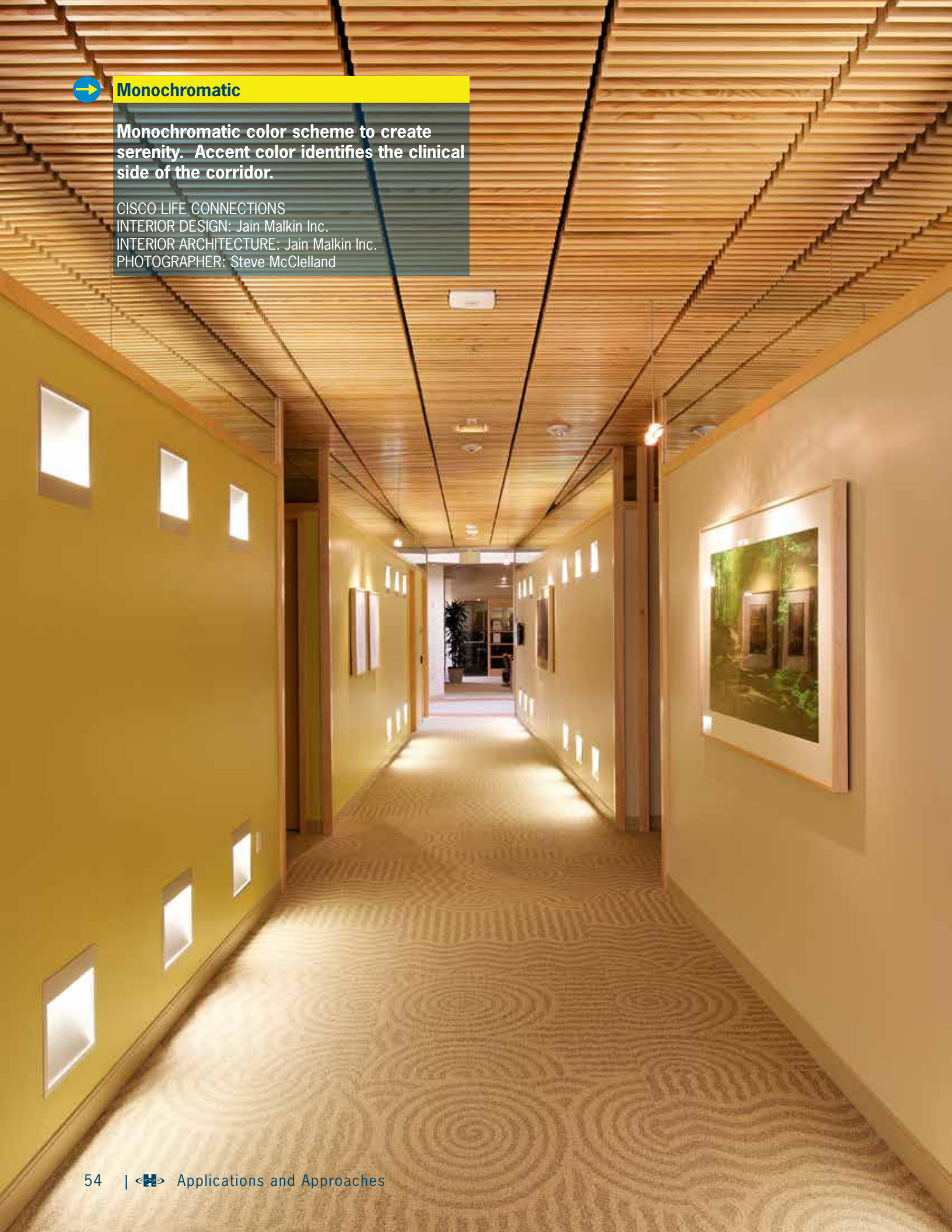
based on opinion and anecdote. Inconsistent findings in the color literature reflect the different methods used, poor study design, conditions, sample sizes, or test protocols. For example, some studies report preferences using only three colors or three shapes, while others report preference using a dozen different colors with two or three different hues of each psychological primary color.

Too few publications report on test-retest reliability, perform statistical analyses, or include the lighting conditions for every color study, as this directly impacts the perceived color. For example, Sosnova, Loseva, and Bukhareva (1999) note the loss of red green perception of luminous objects with 500-1,000 lux. The brightness of the space in which color is tested and the proximity of contrasting colors change the color perceived. Such information is widely documented and should be used when searching for common principles in the literature. Further, many studies use small cards to test color responses, but this is not likely to adequately test architectural color. Scale, dimension, and immersion in color differentially impact study results and should be taken into account. The medium used to display color also creates different perception. Illuminated color on desktop screens and virtual caves are likely to yield different responses and are accompanied by different sensations when compared to applied or painted colors. In conclusion, many studies that are commonly cited as "proof" of the impact of color have little ecological relevance to color selection in healthcare architecture. As long ago as 1933, Poulson and Neilson astutely noted that we must not fail to recognize that a true statement of color preference cannot be generalized from a singular or simple color test.

Interpretation and Translation

Despite the paucity of directly relevant research, critical analysis of findings that span a breadth of evidence from multiple disciplines provide the foundation for suggesting a set of working guidelines relevant to color healthcare environments. In the spirit of evidence-based design, data from rigorous, peer-reviewed scientific and medical studies may be weighted and considered together with empirical, anecdotal, and practical experience to guide color use.

The section that follows reflects the combination of practitioners' experience in order to describe applications and approaches to the use of color in healthcare settings. Professional experience and user responses offer valuable insights to color applications that are well-received.



Monochromatic

Monochromatic color scheme to create serenity. Accent color identifies the clinical side of the corridor.

CISCO LIFE CONNECTIONS
INTERIOR DESIGN: Jain Malkin Inc.
INTERIOR ARCHITECTURE: Jain Malkin Inc.
PHOTOGRAPHER: Steve McClelland

Applications and Approaches

All Children's Hospital; *Interior Design:* Karlsberger and CAMA Inc.; *Architect:* Karlsberger

El Paso Children's Hospital; *Interior Design*: CAMA Inc.; *Architect*: KMD Architects; *Photographer*: Blakely Photography

Despite the lack of consensus in the literature of color in healthcare settings, hospitals and other facilities can still be designed thoughtfully.

Design Considerations

1. Consider the needs of each specific patient population in the selection of color. In elderly populations, understand how vision changes as the eye ages. Greater contrast and more saturated colors are easier to see than pastel tones.
2. Skin color is a vital clinical cue. The patient zone should have access to natural daylight so that clinicians can assess skin tone. Colored walls and surfaces should be arranged so that light does not reflect color from the surface onto the patient. For example, neonates and those with liver disease present with yellowing of the skin from jaundice; yellow or blue surfaces would make observing these conditions more difficult. Patients at risk of low oxygen levels or cyanosis present blue or purple skin coloration; reflection from yellow surfaces could minimize observation of blue skin tone; reflection from blue surfaces could unnaturally enhance a cyanotic tone.
3. Understand the physiological effects of color and psychological perception of color: simultaneous contrast, successive contrast and afterimage, metameric color pairs, reflectance, Purkinje effect, color constancy, advancing and receding colors, figure-ground reversal.

Soin Hospital; *Interior Design*: Jain Malkin Inc.; *Architect*: HOK; *Photographer*: James Steinkamp

Sycamore Hospital; *Interior Design*: Jain Malkin Inc.; *Architect*: LWC Inc.; *Photographer*: Saari & Forrai Photography

Cisco LifeConnections Clinic; *Interior Design*: Jain Malkin Inc.; *Architect*: Jain Malkin Inc.; *Photographer*: Steve McClelland

4. Consider religious or symbolic associations with color, including cultural taboos, bias, and nationality, that may be relevant to that particular community. (For more information about culture and color, see the Appendix).
5. Consider functional factors:
    - Effect of lighting and materials on color.
    - Ages of people who will use the space.
    - Is the space for patients, staff, or visitors, and what is the typical length of time these people will be exposed to these colors?
    - The nature and severity of the illness.
    - The impact of illness or medical condition on color blindness or perception.
    - Suitability of color palette for women, men, and children.
    - Types of tasks: amount of contrast desired for the level of visual acuity and amount of contrast required.
    - Is the goal to emphasize or to camouflage?
    - Is the goal to organize spaces using color as the cue?
    - How much contrast is desirable?
    - Interaction of texture can cause the same color to look different.
    - Use as cueing device in wayfinding.
    - Use to denote hazards or warn of danger.
    - Geographic and cultural bias: In northern climates with long, harsh winters, warm colors might be more appropriate than cool; in the West, the quality of light is a warmer and more intense color than in the East; in tropical areas, strong saturated colors (hot pink, orange, peacock, purple, lime) are often favored. (For a more information about culture and color, see the Appendix)

Miami Valley Hospital South; *Interior Design, Architect*: Gresham, Smith and Partners; *Photographer*: Cliff Ritchey

Clinical Laboratory Yale-New Haven Hospital; *Interior Design*: CAMA Inc.; *Architect*: Karlsberger; *Photographer*: Rick Scanlan

Scripps Center for Integrative Medicine; *Interior Design*: Jain Malkin Inc.; *Architect*: Schmidt Scanlon Gordon; *Photographer*: Michael Campos

6. Understand how color affects the perception of space.
7. Think about practical applications of color psychology.
8. Consider aesthetics: Although studies may indicate that a blue accent wall is desirable for a coronary care patient, for example, the specific hue and its saturation or value coupled with the way the color is used, are entirely dependent on the designer's skill and talent. Therefore, even though the initial development of color palettes may not have been based on intuition or personal taste, the final product still bears the stamp of the individual designer's unique talent.
9. Address a facility's motivation: Many interior design projects are about improving the image of an institution, recruiting and retaining staff, attracting a competitor's customer base, and/or making a statement about the experience or quality of care delivery patients can expect. Color may be tied to an institution's logo or corporate brand, the culture of its constituency, or the perception of the quality of the materials selected.
10. Consider maintenance: Maintenance is extremely important in healthcare. Color plays a role in the perception of clean. Dark colors can show white lint prevalent in healthcare or the cloudy stain of an alcohol-based hand sanitizer. Choices in wood color can also create maintenance nightmares such as the use of darker wood stains that when scratched show a lighter color wood underneath.
11. Take into account attic stock: Healthcare environments are very public spaces and get used 24/7. Materials must withstand a higher level of wear than most environments. The upkeep of such spaces requires that in-house maintenance

Argyros Ambulatory Center at Eisenhower Medical Center; *Interior Design*: Jain Malkin Inc.; *Architect*: Boulder Associates; *Photographer*: Ed LaCasse

Soin Hospital; *Interior Design*: Jain Malkin Inc.; *Architect*: HOK; *Photographer*: James Steinkamp

Soin Hospital; *Interior Design*: Jain Malkin Inc.; *Architect*: HOK; *Photographer*: James Steinkamp

staff keep attic stock of those finishes that need constant refurbishment. Wall and floor finishes are the most common. It is sometimes the mandate of an institution to limit the number of materials or color choices so that attic stock can be maintained. Without evidence to state otherwise, this argument supports a rather neutral healthcare environment given the size of most institutions.

Color and its Effect on the Perception of Space

Interior designers and architects might consider the following regarding the laws of perception and application of color theory (Malkin, 1992).

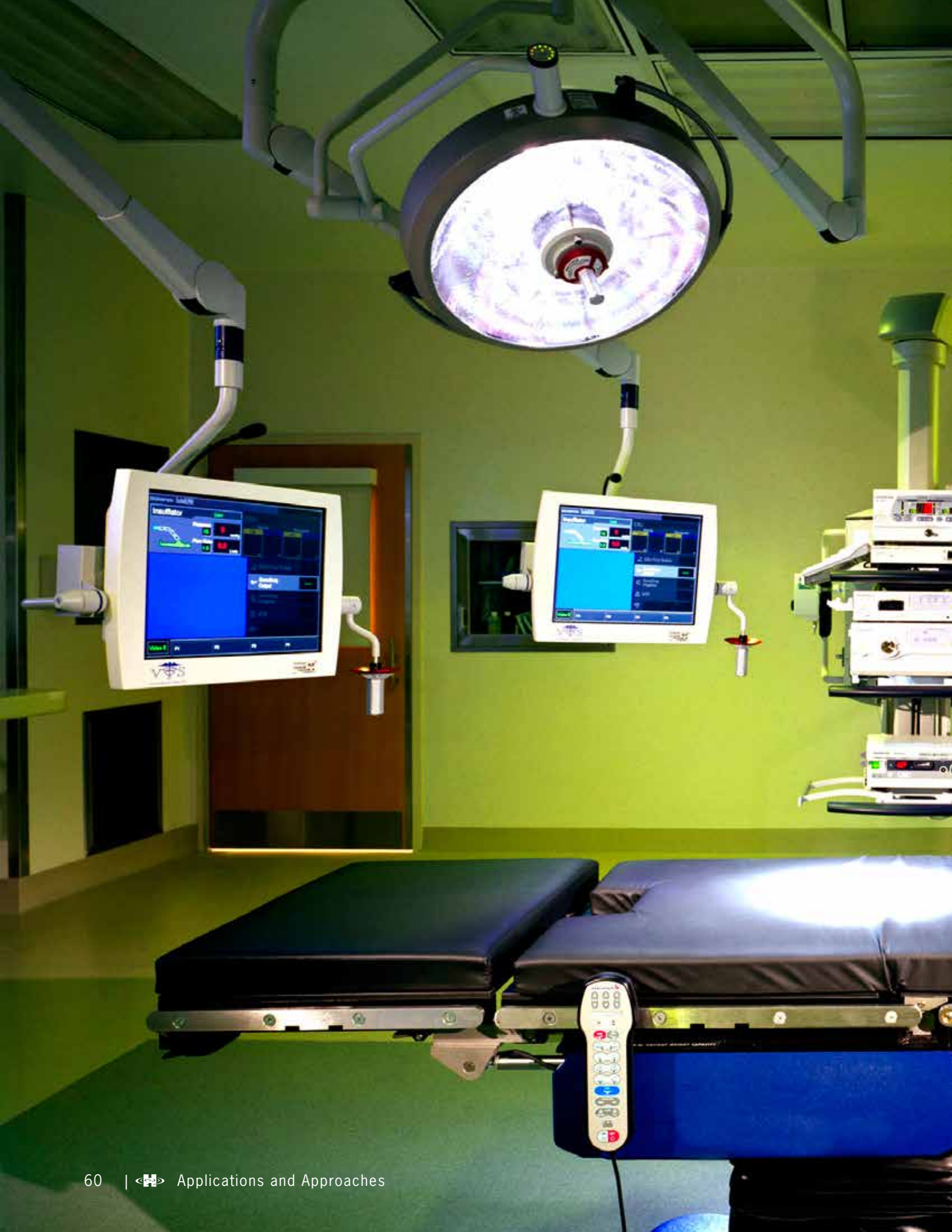
12. To emphasize the color of a specific room, the entry may be painted a complementary color.
13. Color modifies architectural form. It can expand, shorten, widen, lengthen, and give the illusion of lowering or raising a ceiling. Color can change the appearance of the environment so markedly that it can influence an individual's subjective impression of a space.
14. Bright colors appear to be lighter in weight. Ordered from "heavy" to "light" they are: red, blue, purple, orange, green, yellow.
15. Bright objects are overestimated in size. Yellow appears the largest, followed by white, red, green, blue, black, in descending order.
16. A light object appears larger against a dark background. A dark object appears smaller against a light background.
17. The wall opposite a window should generally be kept light, or it will absorb much of the daylight. (However, in a patient room, this approach might create glare if appropriate window treatment is not provided.)

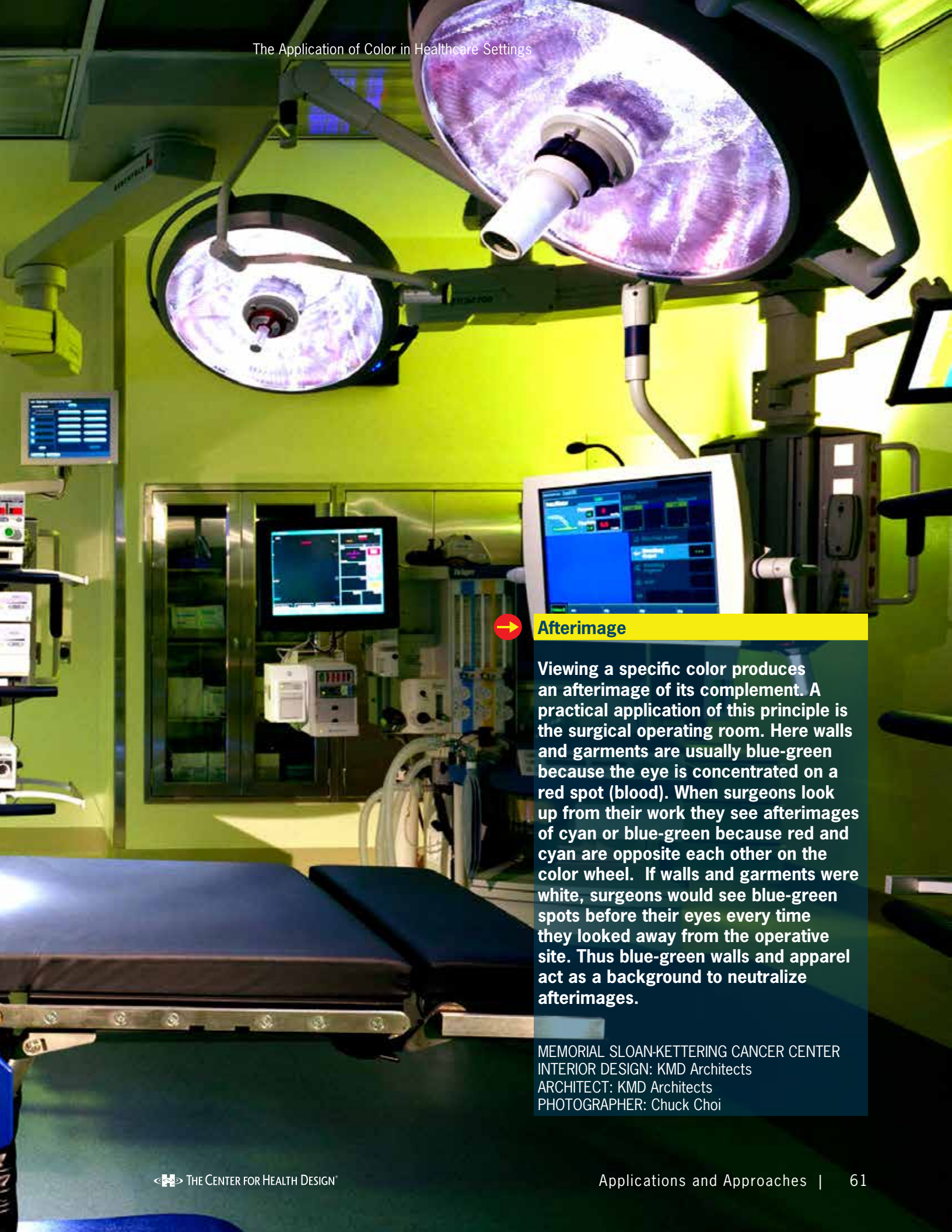
Phoebe Sumter Medical Center; *Interior Design, Architect*: Gresham, Smith and Partners; *Photographer*: Brian Robbins

Curci Cancer Center at Eisenhower Medical Center; *Interior Design*: Jain Malkin Inc.; *Architect*: Moon Mayoras Architects, Inc; *Photographer*: Steve McClelland

Smilow Cancer Hospital; *Interior Design, Architect*: Shepley Bulfinch; *Art and EBD Consulting*: CAMA Inc.; *Photographer*: Rick Scanlan

18. A window wall and frame should be light so as not to contrast too much with daylight sky. High contrast can result in headaches and eyestrain.
19. If a red wall is placed next to a yellow wall, the yellow wall will appear greener than it actually is due to the afterimage of the red: cyan. The blue afterimage of the yellow will cause the red to appear more purple.
20. Warm colors advance; cool colors recede. (Warm colors are long wavelength colors, cool colors are short wavelength.)
21. Light colors and small patterns visually enlarge a space. Dark colors and large patterns make it appear smaller.
22. The absence of variety in the visual environment may cause sensory deprivation (Mahnke & Mahnke, 1987). Those confined to nursing homes, hospitals, and institutions need variety in lighting, wall color, and artwork for their well-being. A variety of colors is essential because an individual quickly adapts to the effects of any one color, no matter how predominant, and it becomes monotonous.
23. According to Kruithof's principle, in low levels of light (under 30 footcandles), the color of objects and surfaces will appear normal when the light source is slightly tinted with pink, orange, or yellow; at higher levels of lighting, objects and surfaces will appear normal when the light source is cooler. Therefore, a "warm" light source is best with low levels of illumination, and a "cooler" light source is best with high levels of illumination (Birren, 1969).
24. The absence of color in a patient corridor (white walls, white floor, and possibly even white baseboards) can create a visual hazard for older

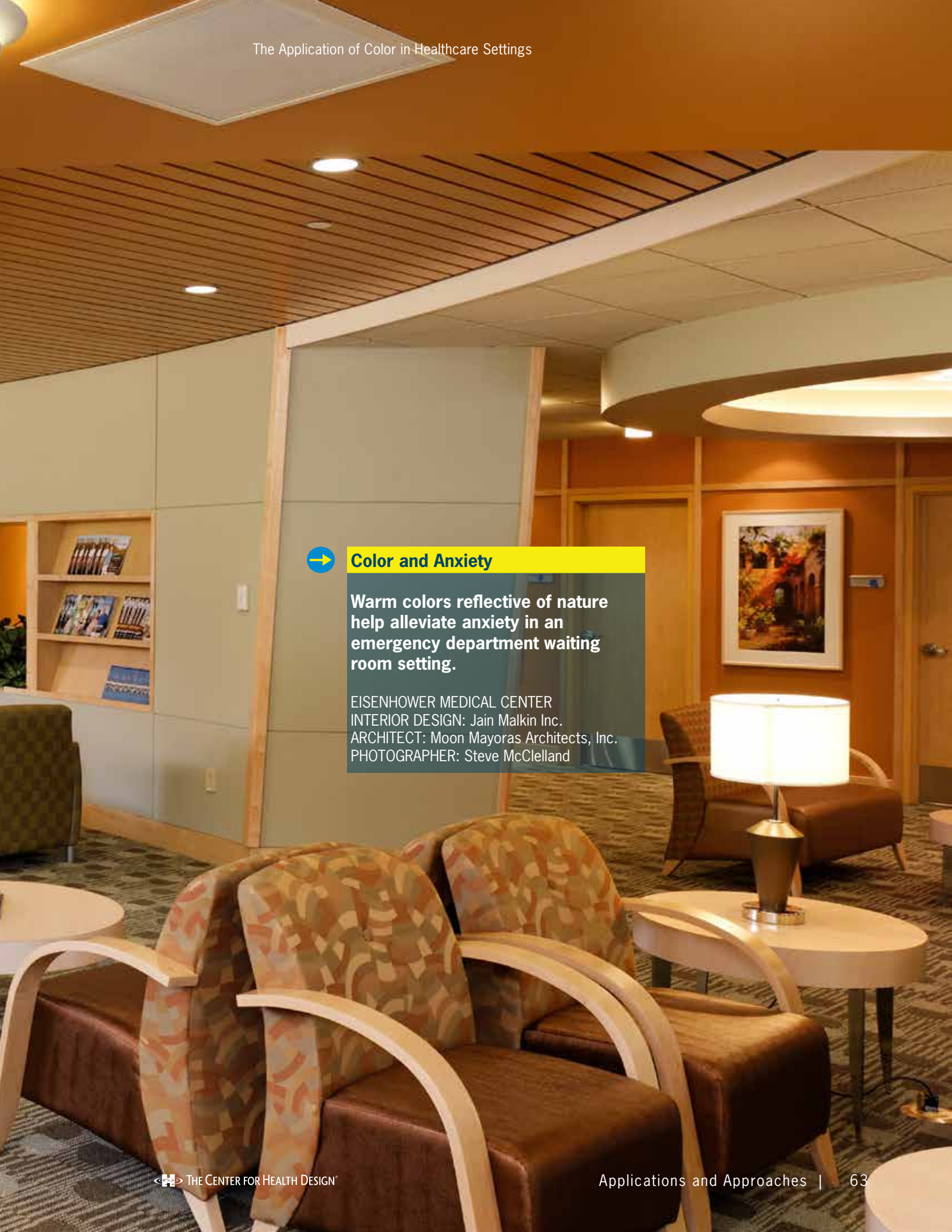




Afterimage

Viewing a specific color produces an afterimage of its complement. A practical application of this principle is the surgical operating room. Here 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 afterimages of cyan or blue-green because red and cyan are opposite each other on the color wheel. If walls and garments were white, 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.

MEMORIAL SLOAN-KETTERING CANCER CENTER
INTERIOR DESIGN: KMD Architects
ARCHITECT: KMD Architects
PHOTOGRAPHER: Chuck Choi



Color and Anxiety

Warm colors reflective of nature help alleviate anxiety in an emergency department waiting room setting.

EISENHOWER MEDICAL CENTER
INTERIOR DESIGN: Jain Malkin Inc.
ARCHITECT: Moon Mayoras Architects, Inc.
PHOTOGRAPHER: Steve McClelland

Smilow Cancer Hospital; *Interior Design, Architect*: Shepley Bulfinch; *Art and EBD Consulting*: CAMA Inc.; *Photographer*: Rick Scanlan

El Paso Children's Hospital; *Interior Design*: CAMA; *Architect*: KMD Architects; *Photographer*: Blakely Photography

Clinical Laboratory Yale-New Haven Hospital; *Interior Design*: CAMA Inc.; *Architect*: Karlsberger; Photographer: Rick Scanlan

persons with reduced visual acuity and even other patients with compromised equilibrium, which could lead to falls. Color can define spatial relationships such as the junctions between walls and floors giving visual cues.

25. Wayfinding: Signage is sometimes overused in healthcare; When used, it should stand on its own and be noticed in a quick glance. Its coordination with the interior's palette should be organized early in the process. Line of sight to the next destination where further information can be imparted is more than enough for a stressed and confused traveler to handle. For instance, rather than signage to point to an obvious direction in a complex building type such as a healthcare facility, would a palette of "color brightness influenced by contrast effects, particularly between objects and background" be much more effective? Small accents of color may play a role in "attention grabbing" assisting as a wayfinding cue.

Sensitivity to Light and Color

26. Since the cones of the eye are concentrated in the center of the retina, color sensitivity decreases toward the periphery of the retina until it reaches the edge where only light and dark can be discriminated. Translating this into a more practical application, the greatest values (brightnesses) and the warm, active colors (yellows, reds, and oranges) should be placed in the center of attention. Lower brightnesses and cool, unsaturated colors (dark green, dark blue, dark brown) should appear on the periphery

Sutter Family Resource Center; *Interior Design*: Jain Malkin Inc.; *Architect*: Ratcliff; *Photographer*: Doug Salin

USF Health Byrd Alzheimer's Institute; *Interior Design, Architect*: Gresham, Smith; *Photographer*: Randy Van Duinen

Scripps Center for Integrative Medicine; *Interior Design*: Jain Malkin Inc.; *Architect*: Schmidt Scanlon Gordon; *Photographer*: Michael Campos

of the visual field. This knowledge is particularly important for the design of graphic signage, posters, large paintings, exhibitions, displays, and interior design. People can be led from one room to another by the skillful arrangement of successive values and colors.

27. Research around diurnal cycles suggests that nurses needing a quick break would prefer spaces that are brightly lit and also have a stronger color palette, while those who need to replenish would prefer to retreat to a room with softer lighting and a darker color palette so they can put their feet up and close their eyes for 20 minutes. This may be particularly true for nightshift workers and should be field-tested.

Practical Applications of Color Psychology

Although the systematic investigation of the effects of color upon human behavior has been long in coming, those studies that do exist are often contradictory and sometimes viewed with skepticism. Despite this, the following observations will be helpful to practitioners (Malkin, 1992).

28. Red and yellows, for example, may be used in settings where creative activity is desired and socialization encouraged; greens and blues in areas that require quiet and extended concentration and high visual acuity (Sharpe, 1974).
29. Cool colors may be appropriate in environments for agitated, hypertensive, or anxious individuals; red may be appropriate in the depressed person's environment. Highly saturated colors should be avoided with autistic schizophrenics, red should be avoided for those afflicted with epilepsy and other neurological diseases (Sharpe, 1974).

Seacrest Village Retirement Community - San Diego Hebrew Homes; *Interior Design*: Jain Malkin Inc.; *Photographer*: Steve McClelland

Yale-New Haven Hospital; *Interior Design*: CAMA Inc.; *Architect*: Salvatore Associates; *Photographer*: Rick Scanlan

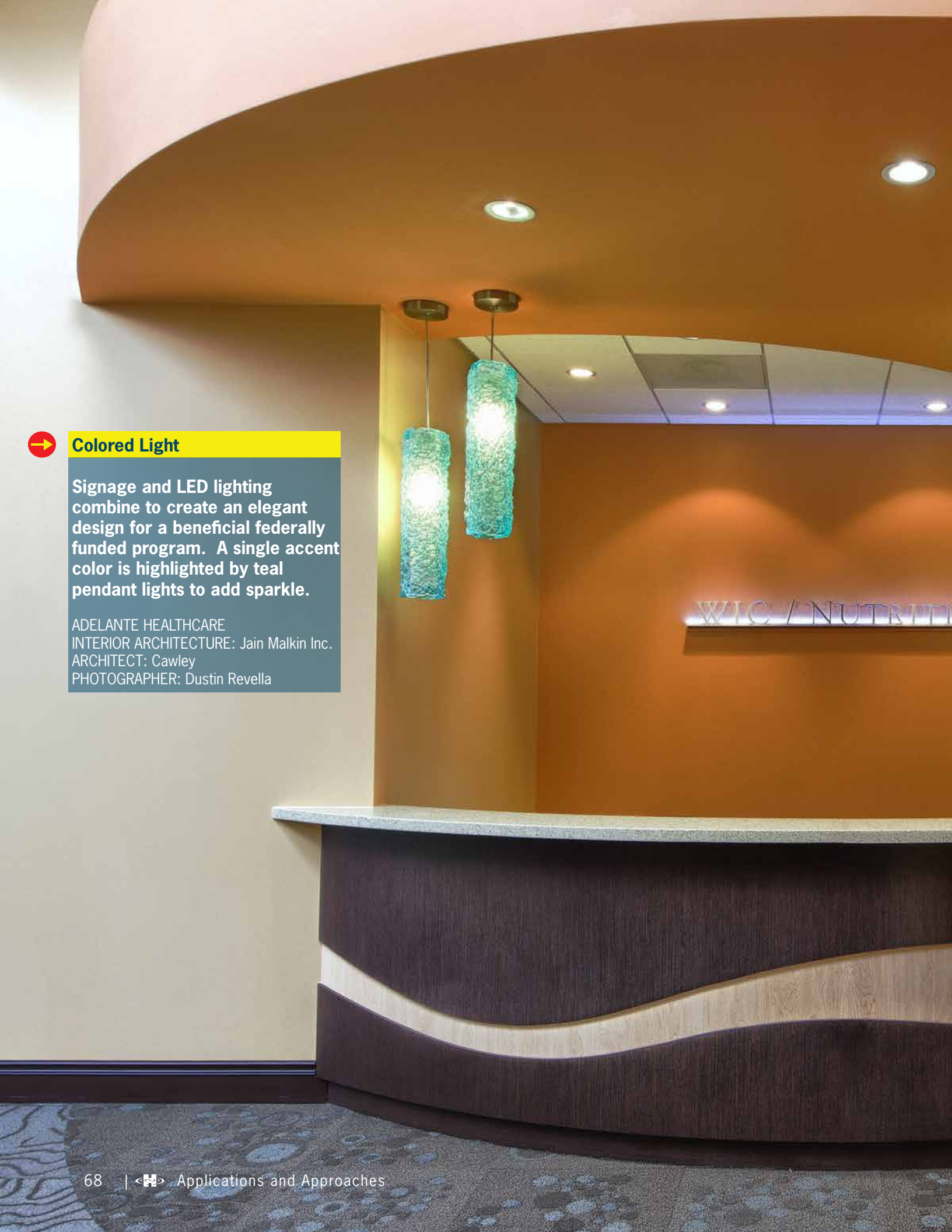
Loma Linda Rehab Hospital; *Interior Design*: Jain Malkin Inc.; *Architect*: HMC Architects; *Photographer*: Through HMC Architects

30. The use of busy patterns or highly stimulating colors should be avoided in settings accommodating those with neurological disorders as they may trigger seizures.
31. Rousing, bright colors are more appropriate in environments for the aged than pastels, which are barely visible to those with failing eyesight.
32. 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.
33. Under warm colors, time is overestimated (one feels one has been there longer than time actually spent), weights seem heavier, objects seem larger, and rooms appear smaller. Under cool colors, time is underestimated (one feels one has been there less time than actually spent), weights seem lighter, objects seem smaller, and rooms appear larger (Birren, 1978). Thus, cool colors may be used when monotonous tasks are performed to make the time seem to pass more quickly. Red and orange are commonly used in fast food restaurants, where quick turnover of tables is desired.
34. Warm colors with high illumination encourage increased alertness and outward orientation; they are good where muscular effort or action is required, such as a physical therapy gym. Cool colors and low illumination encourage less distraction and more opportunity to concentrate on difficult tasks (Sharpe, 1974). Cool colors neutralize the negative effects of noise distraction.

Elementary Institute of Science; *Interior Design*: Jain Malkin Inc.; *Photographer*: Steve McClelland

Memorial Sloan-Kettering Cancer Center; *Interior Design, Architect*: KMD Architects; *Photographer*: Chuck Choi

35. Viewing a specific color produces an afterimage of its complement. A practical application of this principle is the surgical operating room. Here 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 afterimages of cyan or blue-green because red and cyan are opposite each other on the color wheel. If walls and garments were white, 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.
36. Another example of afterimage can be experienced by walking through a corridor that has yellow walls, a warm-toned floor, and incandescent (warm) light source—essentially a yellow-hued environment. Leaving the corridor to enter a lobby produces afterimages of blue, the complement of yellow. This concept is very important for interior design. An understanding of it can prevent a designer from creating undesirable color relationships.
37. In patient rooms, choice of headwall color has both aesthetic and clinical implications. The headwall color can reflect onto the patient's skin and thus skew a physician's diagnostic assessment. In patient bathrooms, select a color that is flattering to skin tones and check it in a light box with the source of lighting to be used around the mirror. Self-appraisal is important to a patient's morale: If lighting is poor and colors are unflattering to skin tones, patients may be shocked at their appearance.

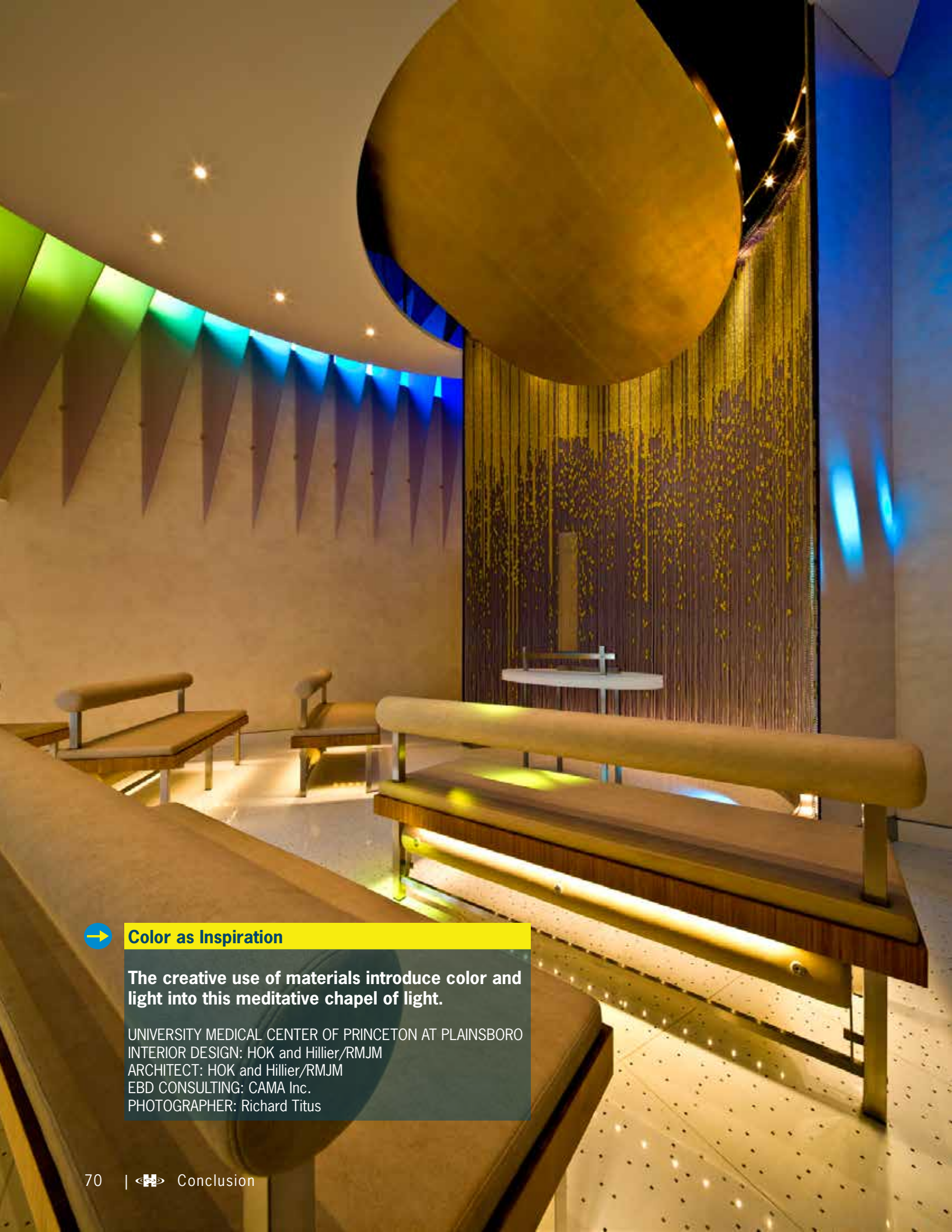


Colored Light

Signage and LED lighting combine to create an elegant design for a beneficial federally funded program. A single accent color is highlighted by teal pendant lights to add sparkle.

ADELANTE HEALTHCARE
INTERIOR ARCHITECTURE: Jain Malkin Inc.
ARCHITECT: Cawley
PHOTOGRAPHER: Dustin Revella

EXIT



Color as Inspiration

The creative use of materials introduce color and light into this meditative chapel of light.

UNIVERSITY MEDICAL CENTER OF PRINCETON AT PLAINSBORO
INTERIOR DESIGN: HOK and Hillier/RMJM
ARCHITECT: HOK and Hillier/RMJM
EBD CONSULTING: CAMA Inc.
PHOTOGRAPHER: Richard Titus

Conclusion

The use of color has long been one of the most subjective aspects of interior design and especially so in healthcare settings. This may account for the fact that many of the newer hospitals are devoid of color. For those who seek validation through evidence-based research, it is very difficult to design color studies for the actual setting of a healthcare facility, therefore, there is little that is definitive in the way that practitioners might wish to find clear principles that can be applied to the healthcare environment.

Nevertheless, there is much value in the assembly of studies noted in this paper to enable the confident practitioner, armed with basic color theory, to understand the sensitivities of each type of patient and each setting and to be able to successfully enhance patients' experiences. Design practitioners educated and trained in the application of color theory and the principles noted above may be timid because the risk of criticism is high. Risk seems to be reduced by the specification of a neutral color palette but can also be reduced with proper evidence to support a broader palette.

This paper encourages a thorough understanding about where, when, and how color can impact the healthcare experience. It presents the best summary to date of studies done on color and encourages further research.

The lack of color (white walls) is unfamiliar to some, considered modern by others, and, for many years, has been one of the hallmarks of what has been referred to as an "institutional" environment. Consider this publication a baseline that perhaps will stimulate much more research about the influence of color. But for now, go forth and use color. The more you do it the more confident you will become.

References

Albers, J. (2006). *Interaction of color*. New Haven: Yale University Press.

Birren, F. (1969). *Light, color & environment*. New York: Van Nostrand Reinhold.

Birren, F. (1978). *Color and human response*. New York: Van Nostrand Reinhold.

Blumberg, R., & Devlin, A. S. (2006). Design issues in hospitals: The adolescent client. *Environment and Behavior*, *38*, 293–317.

Chevreul, M. (1855). *The principles of harmony and contrast of colours, and their applications to the arts* (2nd ed.). (Translated.) London: Longman, Brown, Green, and Longmans.

Coad, J., & Coad, N. (2008). Children and young people's preference of thematic design and color for their hospital environment. *Journal of Child Healthcare*, *12*, 233–48.

Dittmar, M. (2001). Changing colour preferences with ageing: A comparative study on younger and older native Germans aged 19-90 years. *Gerontology*, *47*(4), 219–26.

Edelstein, E. A. (2006). *Translational design: The intersection of neuroscience and architecture*. Thesis, NewSchool of Architecture & Design.

Edelstein, E. A., et al. (2008). The effects of colour and light on health. *World Health Design, 2*, 57–61.

Edelstein, E. A. (2008). The laboratory experiment. In *AIA College of Fellows 2005 Latrobe Fellowship: Developing an evidence-based design model that measures human response: A pilot study of a collaborative, trans-disciplinary model in a health care setting* (pp. 63–132). Washington, DC: American Institute of Architects.

Edgerton, E., Ritchie, L., & McKechnie, J. (2010). Objective and subjective evaluation of a redesigned corridor environment in a psychiatric hospital. *Issues in Mental Health Nursing*, *31*, 306–314.

Gage, J. (1999). *Color and meaning*. Berkeley: University of California Press.

Gerritsen, F. (1975). *Theory and practice of color*. New York: Van Nostrand Reinhold.

Gibson, M., MacLean, J., Borrie, M., & Geiger, J. (2004). Orientation behaviors in residents relocated to a redesigned dementia care unit. *American Journal of Alzheimer's Disease and Other Dementias*, *19*(1), 45–49.

Mahnke, F., & Mahnke, R. T. (1987). *Color and light in man-made environments*. New York: Van Nostrand Reinhold.

Malkin, J. (1992). *Hospital interior architecture*. New York: Van Nostrand Reinhold.

Malkin, J. (2002). *Medical and dental space planning – A comprehensive guide to design, equipment, and clinical procedures*. New York: John Wiley & Sons.

Mather, J., Stare, C., & Breinin, S. (1971). Color preferences in a geriatric population. *Gerontologist*, *11*(4, Pt.1), 311–313.

Park, J. G. (2009). Color perception in pediatric patient room design: Healthy children vs. pediatric patients. *Health Environments Research and Design*, *2*(3), 6–28.

Poulson, M., & Nielsen, B. (1933). Certain color preferences of college students. *Transactions of the Utah Academy of Sciences*, *10*, 87–88.

Redshaw, M., & Smithell, R. (2000). *Children in hospital: The impact of the hospital environment on children, parents and nursing staff*. Bristol, UK: Institute of Child Health.

Rousek, J. B., & Hallbeck, M. S. (2011). Improving and analyzing signage within a healthcare setting. *Applied Ergonomics*, *42*, 771–784.

Schuschke, G., & Christiansen, H. (1994). Patient-related color preference and color design in the hospital. *Zentralbl Hyg Umweltmed*, *195*(5-6), 419–31.

Sharpe, D. T. (1974). *The psychology of color and design*. Chicago: Nelson-Hall Co.

Sosnova, T. L., Loseva, E. I., & Bukhareva, E. A. (1999). The physiological hygiene bases for the requirements for illumination and color decor of the quarters for the station masters. *Gig Sanit*, *3*, 28–31.

Tofle, R. B., Schwarz, B., Yoon, S-Y, & Max-Royale, A. (2004). Color in healthcare environments: A critical review of the research literature. Retrieved May, 1, 2006, from www.cheresearch.org

Varni, J., Seid, M., & Rode, C. (1999). The PedsQL: Measurement model for pediatric quality of life inventory. *Medical Care*, *37*(2), 126–139.

Wijk, H., Berg, S., Sivik, L., & Steen, B. (1999). Color discrimination, color naming and color preferences in 80-year olds. *Aging: Cultural and Experimental Research*, *11*(3), 176–85.

Appendix

Cultural Implications of Color

Colors may affect people from different cultures in different ways, as specific colors have certain connotations in some countries or regions and very different connotations in others. For example, in the United States, the color white is associated with purity, cleanliness, and weddings; whereas in China, white is associated with death and mourning.

In the literature, there are mixed findings regarding the extent to which culture affects human responses to color. Although it is commonly assumed that culture plays a large role in directing human responses to color, much of the literature demonstrates that many color-emotion relationships are "culture-independent." Gao and Xin (2006) studied the emotional responses of 70 subjects to 218 colors using three scales, including warm-cool, weak-strong, and dynamic-passive. When comparing their work to previous research, the authors conclude, "This cross-culture consistency suggests that the relationship between emotion and perception of colors may depend on some innate causation, which may not be influenced by culture and personal experience (p. 417)."

Gao and colleagues (2007) studied the emotional response of 440 subjects from seven regions to 214 different colors, using surveys developed in the subjects' native languages. The regions included Hong Kong, Thailand, Japan, Taiwan, Italy, Spain, and Sweden. Emotional responses were comprised of 12 pairs of words such as light-dark, warm-cool, soft-hard. Subjects from different regions had similar emotional responses to color for the majority of variables (e.g., deep, pale, subdued, striking, etc.) and "despite the different cultural backgrounds, human's responses on these variables are quite similar (p. 228)."

However, there is also literature to support the idea that culture does affect an individual's response to color. Korean pediatric patients' strong preferences for white were found by Jin Gyu "Phillip" Park's recent environmental color study (personal communication, September 6, 2012). Park investigated cultural impacts on pediatric

patients' preferences for patient room wall colors using 50 Korean and 42 American pediatric patients. Six different wall colors (red, yellow, green, blue, purple, and white) were displayed using physical model simulations. Both groups showed similar preferences except for white: Korean pediatric patients reported significantly higher preference scores for white than American pediatric patients.

For adults, Choungourian (1968) reported cultural differences in color preference among 160 American, Lebanese, Iranian, and Kuwaiti university students in Beirut, Lebanon. While red and blue were preferred by Americans, those colors ranked lowest for Kuwaitis. Blue-green was least preferred by Americans, but was most preferred by both Iranians and Kuwaitis.

This is but a taste of the existing evidence, but there is still much to learn about whether or how culture influences human responses to color. Over the years, people have recommended colors for use (or colors to avoid) in various cultures, and while these are oftentimes not scientifically based, they are interesting nonetheless. The table compiles several sources of information regarding the purported cultural connotations of specific colors in selected countries. Decisions regarding the selection of specific colors for products, logos, office design, or healthcare facilities, for example, are sometimes based more on intuition than science. There is a need for more credible research regarding the relationships between color and culture, although this type of research is difficult to conduct.

References

Choungourian, A. (1968). Color preferences and cultural variation. *Perceptual and Motor Skills*, *26*, 1203–1206.

Gao, X-P., & Xin, J. H. (2006). Investigation of human's emotional responses on colors. *Color Research and Application*, *31*(5), 411–417.

Gao, X-P., Xin, J. H., Sato, T., Hansuebsai, A., Scalzo, M., Kajiwara, K., Guan, S-S., et al. (2007). Analysis of cross-cultural color emotion. *Color Research and Application*, *32*(3), 223–229.

Color Connotations By Country

This is a partial list of color connotations by culture. It is not meant to be exhaustive, but as a starting point for reference. It was developed as part of a separate project funded by SYKES, a global leader in providing customer contact management solutions and services in the business process outsourcing arena.

+ ○ ○ + +o ○	**Argentina**	Red is associated with craftsmanship.[4] Silver connotes Gauchos, craftsmanship.[4] Yellow is associated with wealth, religion, ceremony, and visibility.[4]
+ + + + ○ +	**Australia**	Red is associated with the sun (Australia and the Philippines).[4] Green and gold are national colors.[1] Yellow is associated with resurrection and rebirth (Australia and the Philippines).[4] Green is associated with craftsmanship.[4] Tan is associated with the earth (Australia and the Philippines).[4] Brown is also associated with the earth (Australia and the Philippines).[4]
+ +- ○ ○ ○ +	**Brazil**	Red symbolizes visibility and vibrancy.[4] Green is associated with rain forests.[1] Brown is associated with products that are important to the economy (e.g., wood and nuts), yet there are some superstitions that brown is bad luck.[1]
+- +- ○ +- +- +-	**Canada**	In the U.S. and Canada, red is associated with excitement, warning, passion, hot, and spicy.[4] Also in the U.S. and Canada, yellow is associated with visibility, happy, sunny, but also caution and cowardice.[4] Gold is associated with money, wealth, and luminosity (U.S. and Canada).[4] Green (U.S. and Canada) connotes environmental, freshness, masculinity, healthy, envy, jealousy, inexperience.[4] Brown (U.S. and Canada) is associated with dullness, boring, fertile, strength, unprocessed, and poverty.[4] See also comments for the United States.
+ ○ ○ + - +	**China**	Red is the most popular color[1] and is associated with celebration, communism/ government, fire, summer, good luck, joy, and fertility.[4] Red is the color that brides wear, traditionally,[3] and is associated with love and happiness.[5] Green connotes exuberance, birth, and youth; is one of the most popular colors (along with red);[1] and is associated with trustworthiness and dependability,[2] desireability,[4] reliability,[5] and purity.[5] However, green is not well-received in packaging.[1] Gold is associated with wealth, prestige[1], and preciousness, status, and decoration.[4] Yellow is associated with purity, good taste, royalty, and authority.[5] In parts of Asia, gray is sometimes associated with cheap products.[1]
○ ○ ○ ○ ○ +-	**Costa Rica**	Green associated with nature, but also with envy.[1]
○ ○ ○ + ○ +	**Egypt**	Green is the national color and is associated with fertility and strength,[1] as well as vegetation.[4] Yellow is associated with the soul, the sun, happiness, and prosperity.[4] Gold connotes wealth.[4]
+ ○ ○ + ○ o	**Finland**	See comments for Sweden.
- + ○ +- + +	**Germany**	Red is a color of menacing character in German folk cuture[1] and considered unlucky.[2] Red is also associated with fear, anger, and jealousy.[5] Brown is associated with the earth.[4] Yellow is associated with sunshine, but also cowardice and persecution,[4] envy, and jealousy.[5] Gold is associated with wealth.[4] Gray and silver connote sophistication.[1, 4] Green also represents the earth.[4]
+ - ○ + ○ +	**India**	Maroon is an increasingly popular color in advertising.[1] Red is associated with purity[1] and birth.[4] Yellow is associated with the sun and commerce.[4] Green is well-liked and connotes peace and hope[1] and represents nature.[4] Brown is a mourning color.[1]
○ +o ○ +o + +	**Ireland**	Green is one of the most popular colors and was once the national color.[1] Green also is associated with the environment, Catholicism, and quality (UK, Ireland, and Scotland).[4] Brown connotes earthy, honesty, and manual labor (U.K., Ireland, Scotland).[4] Yellow is associated with visibility and rubber (U.K., Ireland, Scotland). Gold connotes royalty (U.K., Ireland, Scotland).[4] Gray is associated with sophistication, elegance, traditional, tasteful, and strength (U.K., Ireland, Scotland).[4]

+ + ○ + - + +	**Italy**	Red connotes fidelity.[4] Brown is associated with the earth, penitence, and humility.[4] Green is associated with spring, fertility, and youth.[1] Gold is associated with divinity,[1] wealth, and luxury, but also greed.[4] Silver is related to wealth, luxury, and craftsmanship.[4]
+ - ○ ○ + ○ +	**Mexico**	Red is associated with sunny, vibrancy, intensity, religion, and death.[4] Yellow symbolizes the sun, and gold is associated with wealth and church adornments.[4] Green represent vegetation.[4]
+ o ○ o ○ +	**Netherlands**	Red is associated with nature, royalty, and the government.[4] Brown is associated with architecture.[4] Yellow relates to food (e.g., cheese, butter).[4] Green symbolizes ecology.[4]
+ ○ ○ + ○ o	**Norway**	See comments for Sweden.
+ + + + ○ +	**Philippines**	See comments for Australia.
+ ○ ○ o ○ +	**Romania**	See comments for Slovakia.
○ + ○ + + +	**Scotland**	See comments for Ireland.
+ ○ ○ o ○ +	**Slovakia**	Red is associated with medicine in Slovakia and Romania.[4] Green symbolizes nature (Slovakia and Romania).[4] Gold is associated with fairy tales.[4]
- + ○ + ○ +	**South Africa**	Red is a color of mourning[1] and is associated with death and bloodshed.[4] Brown connotes the earth.[4] Yellow signifies high rank.[4] Gold is associated with continuous life.[4] Green connotes fertility.[4]
+ - ○ ○ - + + -	**Spain**	Red is associated with blood and aggression, also commonly used in flamenco costumes.[1] Yellow connotes treason.[4] Green jokes are considered to be racy,[1] green is also associated with cheap, as well as agriculture.[4] Gray connotes strength.[4]
+ ○ ○ + ○ o	**Sweden**	Red symbolizes strength (Norway, Sweden, and Finland)[4] and has positive connotations in Nordic countries.[5] Yellow is associated with the heart and warmth (Norway, Sweden, and Finland).[4] Green symbolizes sterility (Norway, Sweden, and Finland).[4]
+ +o ○ + - + +	**United Kingdom**	Red is associated with the crown, power,[1] and masculinity.[5] Green is symbolic of gardening and high-quality products.[1] Gold is linked with royalty, yet sometimes associated with being "low class." See also notes for Ireland.
+ - + - ○ + - + - + -	**United States**	Red is associated with energy and courage, but also violence and communism.[1] Green connotes nature, money, and good luck, but also is associated with inexperience and envy.[1] Gold is associated with wealth, extravagance.[1] Yellow connotes happy and warm, but also cowardly.[4] Brown symbolizes things that are natural, solid, reliable, yet dull and unsophisticated.[1] Gray may symbolize expensive, high tech, or futuristic, and it is the most popular color for cars. However, gray is also associated with gloom and ranks poorly in terms of consumer preference.[1] Gray is also associated (in the U.S. and Canada) with humility, strength, wisdom, and grief.[4] Silver is considered sleek, classy, and modern.[4] See also comments for Canada.

Color Connotation Key + = Positive o = Neutral - = Negative

[1] Morton, J. (2004). *Global color clues and taboos.*

[2] Sable, P., & Akcay, O. (2010). *Color: Cross cultural marketing perspectives as to what governs our response to it.* Paper presented at the American Society of Business and Behavioral Sciences Annual Conference, Las Vegas, NV.

[3] Morton, J. (2011). *Color matters.*

[4] De Botoli, M., & Maroto, J. (2001). *Colors across cultures: Translating colors in interactive marketing communications.* First published with the title "Translating colours in web site localisation" in 2001 in the *Proceedings of the European Languages and the Implementation of Communication and Information Technologies (Elicit) Conference*, University of Paisley.

[5] Aslam, M. M. (2006). Are you selling the right colour? A cross-cultural review of colour as a marketing cue. *Journal of Marketing Communications*, *12*(1),15–30.

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