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RESEARCH ARTICLE

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Color-emotion associations in interiors

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Abstract

Emotional reactions to red, green, blue, and gray colors in a living room were investigated using a self-report measure. Participants first watched a short video of a 3D model of a living room. Next, they were asked to match the living rooms with facial expressions of six basic emotions. The most stated emotions associated for the red room were disgust and happiness, while the least stated emotions were sadness, fear, anger, and surprise; for the green room, neutral and happiness were the most stated emotions, and anger, surprise, fear, and sadness were the least stated ones; for the blue room, neutral was the most stated emotion, while the least stated emotions were anger and surprise. Neutral, disgust, and sadness were the most stated emotions for the gray room. Gender differences were not found in human emotional reactions to living rooms with different wall colors.

KEYWORDS

color, color vision, emotion, gender, interior space

1 | INTRODUCTION

Emotions play a central role in peoples' lives, and they are of interest to everyone. Everyday conversation is loaded with emotion language.[1] Poems, novels, movies, historical accounts, psychological studies, and philosophical discussions provide a host of information about emotions. Even though the term is used frequently, the question "what is an emotion?" rarely derives the same answer from different individuals, scientists or laymen.[2] People find it very difficult to articulate what they thought an emotion to be. They mostly prefer to name some emotions simply such as anger, happiness, or sadness.[3] For those who try to give an explanation, emotion is often described as a feeling with respect to the related phenomena such as a mood or a sentiment. The complexity of emotion is due to its great sensitivity to personal and contextual circumstances.[1] In addition, as the field of emotion is related to psychology and other human sciences such as clinical psychology and psychiatry, psychoanalysis, neurology, neurophysiology, physiological biochemistry, and psychopharmacology, its complexity increases.[4,5]

Color is likewise one of the most dominant elements that affect every part of our lives. It works as a guide for making sense of our environment and affects our behavior through its informational and cultural role.[6] In addition, as it is a phenomenon of a wavelength of light that is transmitted through our eyes, it also has an influence on the quality of our lives. Thus, color influences us both psychologically and physiologically.[7] Moreover, as a vital design element, color has a strong relationship with emotion. These statements are supported by manifestations of color not only in product design and marketing but also in a variety of other fields, such as color therapy, color mediation, and image consulting.[7]

People spend most of their lives in interior spaces that are created by the structures and shells of buildings.[8] It is important to consider the way people exist in different forms of relationships with the built or physical environment when coloring the interiors, buildings, and associated environments.[9] Color can be used for breaking the monotony and enhancing different spaces with their color schemes.[10] Environments that enclose people should be carefully and systematically analyzed in association with color use in order to design environments that can reduce negative outcomes, such as stress or strain, and enhance positive feelings such as happiness, so people eventually prefer, like, and enjoy the spaces they are in. By selecting the proper color of the space, certain visual and emotional effects might be achieved.[11]

2 | COLOR AND EMOTION

People's mood and emotions are influenced by color. Color emotions can be described as emotional feelings evoked by a single color or color combinations and expressed with semantic words.[12] Thus, color, individually or in combination, might evoke both positive feelings such as happiness, energy, excitement, and calmness and negative feelings such as anger, disgust, and sadness. Empirical evidence indicates that emotional responses to the principal hues such as green, blue, and red includes positive emotional responses, followed by intermediate hues such as yellow-red, and blue-green and chromatic colors such as white and black.[13] On the other hand, complementary colors, which are opposite to each other in the color wheel, such as yellow and purple, provide a psychological balance of warmth and coolness.[11]

Color can transmit meaning from emotional or cognitive messages. Some reactions to color are inborn, intuitive, and universal to everyone, while others lay in the body of learned associations that are dependent both on the realities known to everyone and to meanings learned within a particular society in a particular time and place.[14] Thus, human beings accept certain color meanings as facts based on cultural heritage and family values.[15]

Every color has a particular set of meanings. Not only physical but also emotional characteristics can be related to any given color.[16] However, there are universally agreed meanings for red, orange, and yellow, which are associated with fire, and also for blue, green, and violet, which are associated with cool oceans, deep forests, and shadows.[15]

2.1 | Color analysis

Red, blue and green as choromatic colors and gray as a neutral color was researched in the scope of the current study.

2.1.1 | Red

Red is one of the oldest color names. It is the first color with a defined wavelength.[17] It is assumed to be the color of blood and fire. These early associations charged red with passionate emotions. It has a primary implication of excitement, heat, intensity, and force.[14]

Red's positive connotation involves love (red roses, red heart), luck, passion (red blood), sexiness (red lipstick), importance (red carpet), dynamism, excitement, richness, royalty, and courage.[16,18] Red's negative connotations involve war (red uniforms to disguise blood), blood, fire, the devil, revolution and anarchy (red flag), revolution, danger, fire, and bureaucracy.

The term red contains many hues in languages that have only a few terms for color. Red may include hues of all reds and hues from the range of oranges, most yellows, browns, pinks, and even purples.[17] Red becomes *pink* when it is reduced to a tint and loses some of its saturation and psychological intensity.[14] It becomes gentle and feminine with milder warmth, with charm and delicacy. Pink is generally associated with positive emotions: Being "in the pink" means "everything is fine" as when everything is rosy.[15]Its positive connotations include health, sweetness, prettiness, and femininity.[18]

2.1.2 | Green

Green has ambivalent connotations because it is the largest color family distinguishable to the human eye.[18] It has its own meanings, although it is made from blue and yellow.[16] Yellow supplies it with some pleasant characteristics, while blue makes it seem calmer.[14] It is associated with grass, trees, and other vegetation, and all these make it calming and restful to the eyes. This is also commonly related with health and well-being, making green the most restful color.

Green's positive connotations include environment, growth, and renewal in spring, fertility, freshness, nature, youth, health, peace and calm, things that are cool and refreshing, wealth, and money.[16,18,19] Green's negative connotations include witch craft, jealousy, envy, poison, immaturity, rawness, and sourness.

2.1.3 | Blue

It is the coolest of the cool colors and has no inclusion of warmer tones.[14] It symbolizes infinity and serenity in relation to the sky and the sea that surround human beings.[15] On the other hand, it also symbolizes depression, sadness, and isolation. In addition, bright blue can be a lively color, but it can also lower the body temperature, pulse rate, and blood pressure, which stands in opposition to red in its physical effects.[14]

Blue's positive connotations involve heaven, coolness, truth, tranquility, conservatism (in appeal), loyalty and dependability, security, sky/water, and eyes.[16,18,19] Blue's negative connotations involve introversion, sadness, depression (the winter blues), things that are cold such as frost or ice (blue with cold), drowning or illness (turning blue), and melancholy.

2.1.4 | Gray

Gray is the mixture of black and white. It is a neutral that can range not only from light to dark but also from totally neutral (nonchromatic) tones to warmer tones that are the mixture of chromatic tones with white and black.[14] Light gray does not have strong associative implications as dark gray. Gray in darker tones shares the positive and negative characteristics of black.

Gray is associated with technology, machines, aircraft, concrete, cement, and the urban environment.[15] It implies confusion, loss of distinction (gray area), intelligence, shadow, and work (people in gray suits).[18] It also represents the wisdom of age (gray hair). Light gray, especially in warm toned versions, are useful as background tones.[14]

Studies on the symbolic associations of color were and are still essential for empirical color emotion studies. A great deal of research has been conducted on the relationship between human emotions and color without any reference to interior spaces. Table 1 illustrates the emotional associations of color based on studies in the literature.

3 | THE EXPERIMENT

3.1 | Aim of the study

Color as a design element has influence on human psychological and physiological responses as it evokes discrete feelings. In this context, it constitutes a key factor in the relationship between people and their surroundings. Consequently, environments that enclose people should be carefully and systematically analyzed in association with color use in order to design environments willing to reduce possible threats to their users. Thus, the main objective of this study is to examine the relationship between two crucial phenomena of design *color* and *emotion* in interior spaces. While analyzing this issue, the research question is designated as follows: How would emotional reactions to different colors in an interior space differ?[20]

TABLE 1 Emotional associations of red, green, blue, and gray colors in the literature

Color	Emotions	
Chromatic colors	Positive emotions	Negative emotions
Red	Happiness, surprise, energetic, powerfulness, enjoyment, passionate, love	Sadness, anger, fear
Green	Happiness, calmness, peacefulness, hopefulness, relaxation, comfort, modernism	Aversion, boredom, fearfulness, anxiety, sadness, annoyance, mystery, neutral, nonemotional
Blue	Happiness, calmness, surprise, peacefulness, relaxation, modernism, harmony, serenity	Sadness, fear, dull, cold
Neutral	Positive emotions	Negative emotions
Gray		Sadness, anger, boredom, depression, unemotive

In addition to the stated focuses, the other objective of the study is to develop a matrix between colors and emotions associations in interior spaces that would visualize the colors and their associations with different emotions. Thus, there is an expectation to find the influence of the use of different colors in interior spaces on human emotions.

3.2 | Method of the study

3.2.1 | Sample group

The study recruited 180 people who are students enrolled in a research university.[20] They were chosen by stratified quota sampling on the basis of their design background and gender. Providing a sample that does not have a design past is thought to be important to be able to supply information specifically from the user perspective to designers and interior architects. Thus, persons who had a relation to design, such as being a student in the Faculty of Art, Design and Architecture, were excluded from the study.

The group needed to be balanced with regard to gender (90 females and 90 males) to explore gender differences in color-emotion association in interior spaces. The age of the sample group ranges from 17 to 26 years, and the majority of the participants were between 19 and 22 years of age (75.63%). The mean age of the sample group is 21.08 years.

Participants' familiarity with the computer was enquired about before conducting the experiment. All of the participants were familiar with the computer.

3.2.2 | Setting description

The experiment was conducted at one of the 17 private booths of the University Library Multimedia Room, which covers music and film collections. The booth was chosen as an experiment setting because it supplies an isolated area in which there is no obvious interaction between the inside and outside. Moreover, the library is frequently used by students who are studying in different departments. Thus, it has a power of gathering diverse people. The sample group for this study includes students who do not have a design past. As the library provides this opportunity, and the Multimedia Room supplies a special space for conducting the experiment, a decision was made to use it as the setting.

The booth had both artificial and daylight illumination. To fix the variables in the experiment setting, one booth without any daylight illumination was selected. However, one side of the selected booth had a window pane. Therefore, during the experiment, participants might be affected or disturbed by the outside view. In order to control the

potential problem, the window pane was made passive by covering it with a black curtain.

The illuminance level was measured with a Minolta Illuminance Meter T-10 to understand the lighting situation in the booth after the black curtains were mounted, and it was maintained the same during the experiment. The illuminance level was fixed at 219 lx. A Philips Master TLD-18 W/840 fluorescent lamp was used in the coves for lighting the experiment booth.

The sitting arrangement in the booth was organized to achieve the best control of possible veiling reflections[1] on the computer screen (Figure 1). In addition, participants were faced by an unobstructed surface because of this interior arrangement.

3.3 | Procedures

3.3.1 | Selecting the function

In this study, the main goal is to discover human emotional reactions to individual colors in an interior space. In order to specify the kind of space, user requirements and human needs are analyzed carefully and translated into a spatial context. In this research, a *living space* was studied.[20]

The layout of spaces as physical settings should satisfy the needs in relation to their function. All functions that take place in living rooms, such as conversing and watching television, are analyzed, and the required furniture—a bookcase, a television (TV) unit, couches, and a coffee table—are selected and arranged (Figure 2). The main concern in the configuration of the living room layout was to provide a seating arrangement that is ideal for creating an intimate chatting space. The book case with the TV unit works as a focal point. Thus, the focal attention will be on this one area to which eyes will naturally be drawn. In addition, the furniture arrangement does not create an obstacle for the circulation.

FIGURE 1 A view showing the interior organization of the experiment setting

In this study, it is critical to distinguish the emotional response to color; thus, other stimulations should be minimal. The main variable is set to be the wall color as the walls would be the first visually perceptible areas within the visual field when first entering a room. In order to achieve this:

1. Furniture, floor, and ceiling colors are –gray—because of its lack of hue—in all spaces as the main variable is the wall color,
2. Simplicity is another design criterion in decor, line, and style of furniture and textures,
3. Spaces are generic and conventional to eliminate the role of design itself,
4. Natural light or any other special lighting products are not used to remove the lighting effect.

3.3.2 | Specifying the colors

In this experiment, the interior spaces were shown to participants on a computer screen. Computer monitors use the RGB color model as their method to manage colors. Thus, a computer monitor may allow a wide range of RGB colors. Since the RGB color model is based on the way light mixes on a computer screen, Additive Color Synthesis-RGB Color Model was used in the specification and selection of colors in this study. The same computer screen was used in the experiment as different monitors may display the RGB model different.

In the experiment, the colors chosen are primary additive colors (red, green, blue), and an achromatic color was chosen as a control tool for the lack of hue. In experiments concerning color, it is important to use colors with the same brightness and saturation to control for the variables. The aim

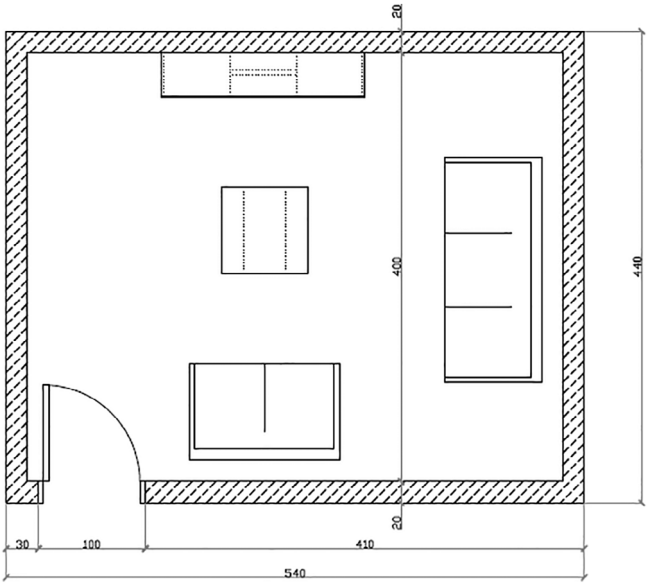

FIGURE 2 Layout of the living room viewed

is to change only the hues while keeping the brightness and saturations of colors the same in order to understand the effect of hue. Therefore, the brightness (B value) and saturation (S value) rates were kept the same for each of the four colors (Table 2). According to the Illuminating Engineering Society of North America[22] guideline, 50% is the recommended reflectance value[2] for wall surfaces.[21] Based on this information, the brightness of colors was adjusted to 50 as they were used for wall surfaces.

To eliminate the possible effects of furniture, ceiling, and floor colors within the same interior space, these elements were also colored in gray to achieve a lack of hue. To discriminate furniture, floor, and ceiling from each other, they needed to be perceivably different. Thus, these were chosen according to IESNA recommendations. IESNA recommends 70% reflectance value for ceiling and 20% reflectance value for floor in indoor spaces. Thus, the brightness level for the ceiling was adjusted to 70 and for the floor to 20. For the furniture, it was adjusted to 60. All the spaces shown thus had the same gray at the same instances (Table 2).

3.3.3 | Creating the interior space

Interior spaces for the experiment were created in a virtual environment (VE). The VE was four different wall-colored living rooms, and they were designed in Second Life (SL) (Figure 3 for an example of a living room). The reason for using SL is its closeness to real-world perceptual experience and its user-friendly interface.[23] Users are able to navigate by walking, flying, and teleporting between spaces.

After creating the four different wall-colored interior spaces in SL, videos for all those spaces were generated using the CamStudio 2.6 Beta program. Each video is 35 seconds long, starting from the entrance (door) of the space and ending again at the same point.

TABLE 2 Selected colors from RGB additive color model

Groups	Colors	RGB values	HSB values
Wall color I	Pure red	R: 255 G: 0 B: 0	H: 0 S: 100 B: 50
Wall color II	Pure green	R: 0 G: 255 B: 0	H: 120 S: 100 B: 50
Wall color III	Pure blue	R: 0 G: 0 B: 255	H: 240 S: 100 B: 50
Wall color IV	Gray	R: 128 G: 128 B: 128	H: 0 S: 0 B: 50
Floor color	Gray	R: 51 G: 51 B: 51	H: 0 S: 0 B: 20
Ceiling color	Gray	R: 179 G: 179 B: 179	H: 0 S: 0 B: 70
Furniture color	Gray	R: 153 G: 153 B: 153	H: 0 S: 0 B: 60

3.4 | Phases of the experiment

The study was conducted in two phases.

In the first phase, participants were asked to fill in a brief questionnaire where they were asked their gender, age, department of study in the university, and usage of computers.

The participants were asked if they had any eye or vision deficiencies. Participants who have any vision deficiencies were asked to participate in the experiment with their correction equipment, such as contact lenses or eyeglasses, which they wore regularly. There were no participants with severe eye or vision damage, who needed to be excluded from the experiment.

Participants were also given *Ishihara's Tests for Color-Blindness*[24] in the very same room with the experimental setup, under the same lighting conditions. After this test, participants were informed about the main objective and procedure of the experiment, both in written form and orally.

In the second phase, there was a 3D living space with four versions. For each space, all walls as one of the major elements of an interior space were colored with the four chosen colors (red, green, blue, and gray) separately. Thus, there were same 3D interior spaces with four different wall colors.

Each participant was shown the same space with two different colors. It is critical to eliminate the possible effect of a definite sequence of seeing colors. To control that effect, the sequences of showing the colors were changed systematically

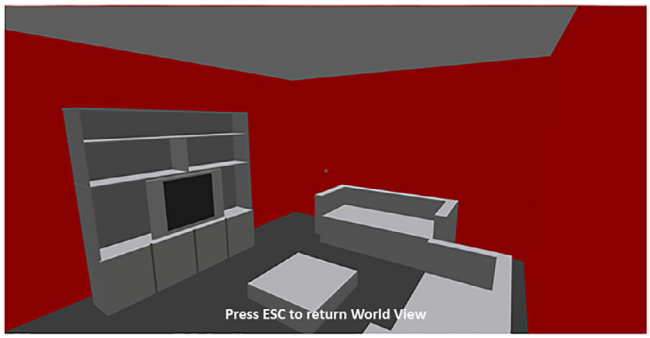

FIGURE 3 A view from red wall-colored living room

(Table 3). According to this strategy, there were six different experiment sets, and in each, the sequences were different. For each set, there were 30 participants (15 female, 15 male). Thus, 180 participants were enrolled in the study with respect to gender and different experiment sets.

A self-report measure of emotion was used in the experiment to give the participant the opportunity to express information to which only she or he has access. A matching measure in between colored interior spaces and expressive emotional faces was used in addition to an open-ended measure.

The colored interior space and emotion matching task comprised four colored stimuli and seven faces expressive of six basic emotions and one neutral, including anger, disgust, surprise, happiness, fear, sadness, and representation of the neutral face expression (Figure 4). First, the participant was seated in front of the computer individually and was shown one 3D interior space video with one specific wall color. Then, he or she was shown the seven faces with no written name of the emotion. He or she was asked to choose a single face representing a specific emotion that best fit the shown colored interior space. The age and gender of the stimulus face shown in the photographs were held constant with the seven faces. To reduce the influence of colored photographs on emotion, photographs used were in black and white, chosen from Ekman's universal representativeness of basic emotions.[25] Second, after choosing a face, each participant was encouraged to state the reason for choosing that specific face. No time limit was stipulated. One participant was shown two spaces and did the matching scale twice.

4 | FINDINGS

Findings from the statistical analyses are demonstrated with respect to the experiment sets involving colored rooms created by the primary additive colors (red, green, and blue) and the color gray sequentially. For each colored room, findings begin with the effect of the sequence of the colored rooms, continue with the effect of gender on emotional associations to colored rooms, and end with the frequencies that indicate the distribution of emotions to colored rooms (Table 4 for an overview of frequencies). In addition, for each experiment set, the comparison of red, green, and blue wall-colored rooms with the gray room is given separately in order to understand if there is a difference in their emotional associations.

Each experiment set embodied the rooms with a chromatic colored wall (red, green, and blue) and the gray color. In each experiment set, there were 60 participants (30 female, 30 male) in total. Different participant groups viewed different experiment sets, so there is no order effect to ensure that learned experiences would not affect the outcome. The sequences of experiencing the colored room were changed systematically in order to control for the effect of order (Table 3). The first 15 females and 15 males first experienced the gray room and then the red room. The following 15 females and 15 males experienced the red room first, followed by the gray room.

4.1 | First experiment set—red room

The first experiment set involved the rooms with red and gray colors.

TABLE 3 Experiment sets showing the number of participants with the sequence of colors

		Sequence of color	Participants	
	Set 1	Gray, Red	30 (15 female, 15 male)	60
	Set 2	Red, Gray	30 (15 female, 15 male)	(30 female, 30 male)
Experiment	Set 3	Gray, Green	30 (15 female, 15 male)	60
sets	Set 4	Green, Gray	30 (15 female, 15 male)	(30 female, 30 male)
	Set 5	Gray, Blue	30 (15 female, 15 male)	60
	Set 6	Blue, Gray	30 (15 female, 15 male)	(30 female, 30 male)
Total			180 (90 female, 90 male)	

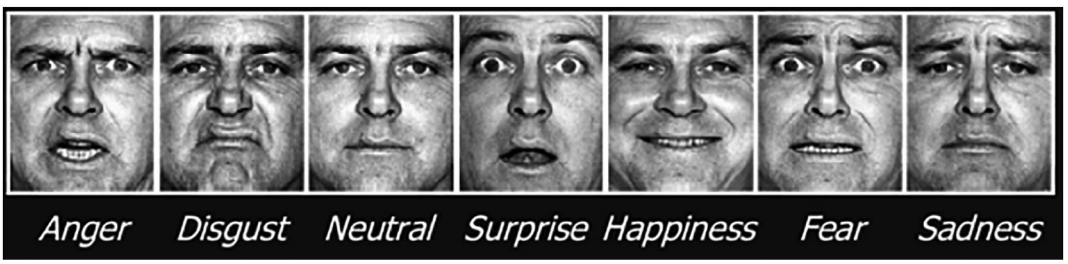

FIGURE 4 The facial expressions of six basic emotions used in the study[25]

TABLE 4 The frequency distribution of emotions on the colored rooms

	Experiment sets						
	First experiment set		Second experiment set		Third experiment set		
Emotions	Red room	Gray room	Green room	Gray room	Blue room	Gray room	Gray room in total
Anger	3	1	2	0	3	0	1
Disgust	21	22	9	23	8	15	60
Neutral	9	20	15	18	25	23	61
Surprise	4	1	2	0	4	0	1
Happiness	20	0	27	2	8	2	4
Fear	2	2	3	0	6	0	2
Sadness	1	14	2	17	6	20	51
Number of participants	60		60		60		180

4.1.1 | Red room

To determine the effect of order, an Independent Sample (Two-Sample) *t* test was conducted. The *t* test demonstrated that there is no significant effect of seeing red room before or after the gray room on the emotional reactions to the red room ($F = 1.620$, df = 58, $\rho = 0.359$).

The effect of gender on emotional reactions to the red room was analyzed using the Independent Sample *t* test. The test shows that there is no significant difference between gender groups in their emotional reactions to red room ($F = 3.242$, df = 55.682, $\rho = 0.803$). Thus, gender has no influence on human emotional reactions to the red room (Figure 5).

The findings for emotional associations to the red room of all 60 participants' who experienced the red room are as follows:

The equality of parameters of multinomial probability distribution of seven emotions was tested using the Chi-square goodness-of-fit test. In this study, the attention is on the frequency of distribution of seven emotions used in the experiment. According to the analyses, the parameters are not equal ($\chi^2 = 51.067$, df = 6, $\rho = 0.000$), and this indicates that, for the red room, the proportion of participants with seven emotions are not the same. In other words, the distribution of emotions for 60 participants is different. The percentages from the highest to lowest are as follows: *disgust* (35%), *happiness* (33.3%), *neutral* (15%), *surprise* (6.7%), *anger* (5%), *fear* (3.3%), and *sadness* (1.7%).

4.1.2 | Gray room

According to the Independent Sample *t* test, there is no significant effect of seeing the gray room before or after the red room on the emotional reactions to the gray room ($F = 6.363$, df = 55.214, $\rho = 0.414$).

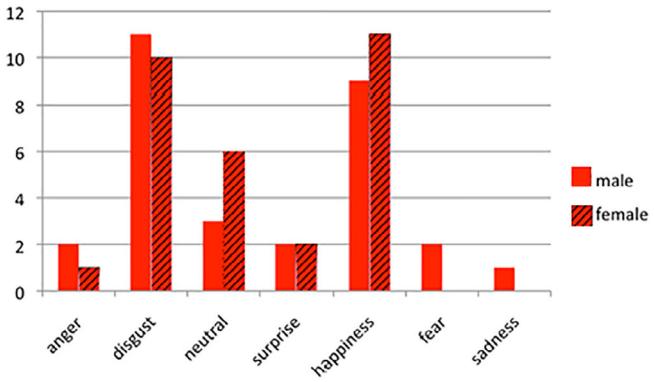

FIGURE 5 The distribution of emotions for the red room with respect to gender group

The Independent Sample *t* test demonstrates that there is no significant difference between gender groups in their emotional reactions to the gray room ($F = 7.863$, df = 54.849, $\rho = 0.345$). Thus, gender has no influence on human emotional reactions to the gray-colored room in the first experiment set (Figure 6).

The equality of parameters of multinomial probability distribution of seven emotions was tested. The test shows that the parameters are not equal ($\chi^2 = 48.600$, df = 5, $\rho = 0.000$). The gray room was associated with basic emotions that are universally accepted except *happiness*. The gray room was not associated with *happiness*. The percentages from the highest to lowest are as follows: *disgust* (36.7%), *neutral* (33.3%), *sadness* (23.3%), *fear* (3.3%), *surprise* (1.7%), and *anger* (1.7%).

Emotional associations to the red room and gray room were compared using a Paired Samples *t* test. The analysis points out that there is a significant difference between the red room and gray room in terms of their associations with emotional reactions (df = 119, $\rho = 0.000$).

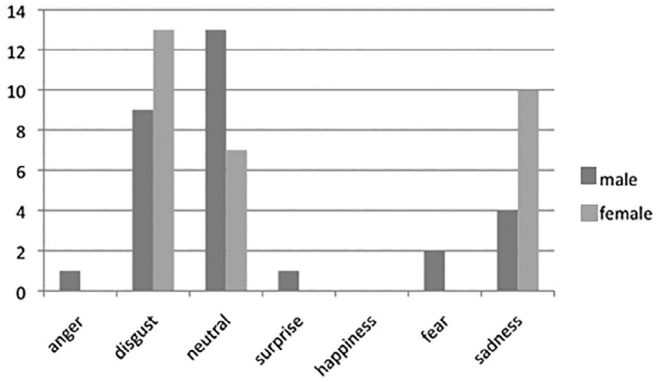

FIGURE 6 The distribution of emotions for the gray room with respect to gender group

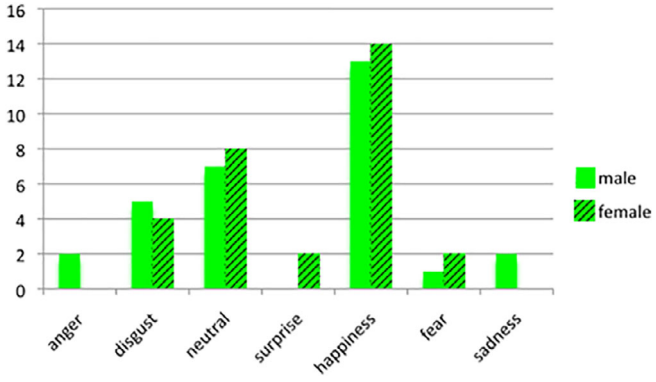

FIGURE 7 The distribution of emotions for the green room with respect to gender group

4.2 | Second experiment set - green room

The second experiment set involved the rooms with green and gray colors.

4.2.1 | Green room

An Independent Sample *t* test shows that there is a significant effect of seeing the green room before or after gray room on the emotional reactions to the green room ($F = .019$, df = 57.549, $\rho = 0.012$). Thirty participants who experienced the green room after the gray room associated the green room with all seven emotions tested. The percentages from the highest to lowest are as follows: *happiness* (56.7%), *neutral* (13.3%), *disgust* (10%), *fear* and *sadness* (6.7% for each), and *anger* and *surprise* (3.3% for each). Thirty participants who experienced the green room before the gray room associated the green room with all emotions except *sadness*. The percentages from the highest to lowest are as follows: *neutral* (36.7%), *happiness* (33.3%), *disgust* (20%), *anger*, *surprise*, and *fear* (3.3% for each).

The Independent Sample *t* test shows that there is no significant difference between gender groups in their emotional reactions to the green room ($F = 4.513$, df = 54.048, $\rho = 0.727$). Thus, gender has no influence on human emotional reactions to the green room (Figure 7).

The equality of parameters of multinomial probability distribution of seven emotions was tested. The test shows that the parameters are not equal ($\chi^2 = 22.000$, df = 5, $\rho = 0.001$). The percentages from the highest to lowest are as follows: *neutral* (36.7%); *happiness* (33.3%); *disgust* (20%); and *fear*, *anger*, and *surprise* (3.3% for each).

4.2.2 | Gray room

According to the Independent Sample *t* test, there is no significant effect of seeing the gray room before or after the green room on the emotional reactions to the gray room ($F = 8.825$, df = 55.461, $\rho = 0.303$).

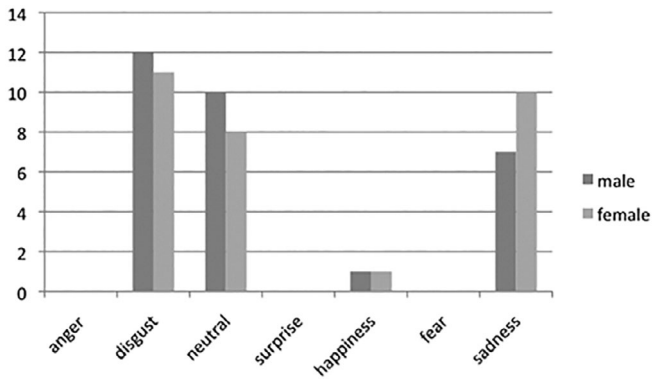

FIGURE 8 The distribution of emotions for the gray room with respect to gender group in the second experiment set

The Independent Sample *t* test demonstrates that there is no significant difference between gender groups in their emotional reactions to the gray room ($F = 2.266$, df = 58, $\rho = 0.431$). Thus, gender has no influence on human emotional reactions to the gray-colored room in the second experiment set (Figure 8).

The equality of parameters of multinomial probability distribution of seven emotions was tested. The test shows that the parameters are not equal ($\chi^2 = 16.400$, df = 3, $\rho = 0.001$). The gray room was associated with basic emotions that are universally accepted, except *anger*, *surprise*, and *fear*, without regarding the gender differences and sequence of showing the spaces. The percentages from the highest to lowest are as follows: *disgust* (38.3%), *neutral* (30%), *sadness* (28.3%), and *happiness* (3.3%).

Emotional associations to the green room and gray room were compared using the Paired Samples *t* test. The analysis points out that there is a significant difference between the green room and gray room in terms of their associations with emotional reactions (df = 119, $\rho = 0.000$).

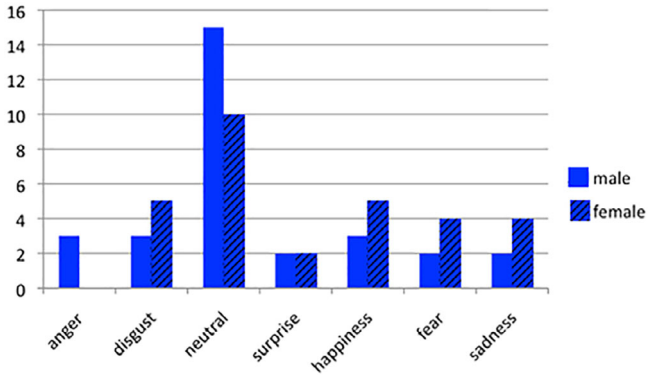

FIGURE 9 The distribution of emotions for the blue room with respect to gender group

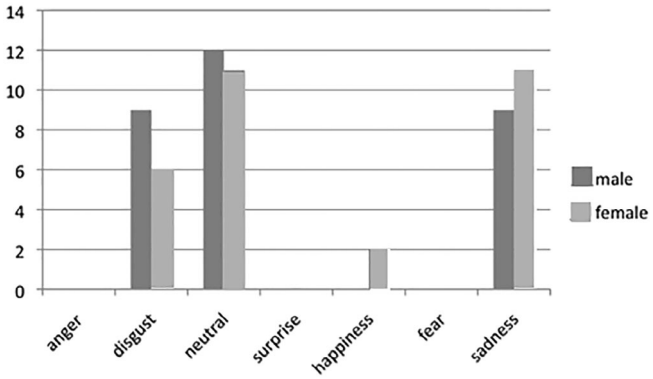

FIGURE 10 The distribution of emotions for the gray room with respect to gender group

4.3 | Third experiment set - blue room

The third experiment set involved the rooms with blue and gray colors.

4.3.1 | Blue room

The Independent Sample *t* test shows that there is no significant effect of seeing the blue room before or after the gray room on the emotional reactions to the blue room ($F = 0.000$, df = 58, $\rho = 0.880$).

According to the Independent Sample *t* test, there is no significant difference between gender groups in their emotional reactions to the blue room ($F = 1.870$, df = 58, $\rho = 0.092$). Thus, gender has no influence on human emotional reactions to the blue room (Figure 9).

The equality of parameters of multinomial probability distribution of seven emotions was tested. The test shows that the parameters are not equal ($\chi^2 = 39.167$, df = 6, $\rho = 0.000$). The percentages from the highest to lowest are as follows: *neutral* (41.7%), *disgust* and *happiness* (13.3% for each), *fear* and *sadness* (10% for each), *surprise* (6.7%), and *anger* (5%).

4.3.2 | Gray room

The Independent Sample *t* test shows that there is no significant effect of seeing the gray room before or after the blue room on the emotional reactions to the gray room ($F = 2.765$, df = 58, $\rho = 0.202$).

According to the Independent Sample *t* test, there is no significant difference between gender groups in their emotional reactions to the gray room ($F = 0.370$, df = 58, $\rho = 0.364$). Thus, gender has no influence on human emotional reactions to the gray-colored room in the third experiment set (Figure 10).

The equality of parameters of multinomial probability distribution of seven emotions shows that the parameters are not equal ($\chi^2 = 17.200$, df = 3, $\rho = 0.001$). The frequencies from highest to lowest are as follows: *neutral* (38.3%), *sadness* (33.3%), *disgust* (25%), and *happiness* (3.3%). The gray room was not associated with *anger*, *surprise*, and *fear*.

Emotional associations to the blue room and gray room were compared using the Paired Samples *t* test. The analysis points out that there is a significant difference between the blue room and gray room in terms of their associations with emotional reactions (df = 119, $\rho = 0.000$).

5 | DISCUSSION

This study comprises three major phenomena, namely, "color," "emotion", and "interior space." The main objective is to investigate the influence of different colors in interior space on human emotional reactions. Emotional associations with four different colors were tested in the study. It was hypothesized that emotional reactions to different colors in an interior space differ. In addition, this study investigated gender differences on color-emotion associations. The selected colors for the study were *red*, *green*, and *blue*. *Gray* was also tested as an achromatic, "neutral" color, used as a control tool. The colors and their associations with emotions were analyzed individually.

Findings of the study were analyzed according to the experiment sets involving colored rooms of red, green, and blue. The first experiment set embodied the red room. The frequency distributions indicated that the participants associated the emotions of *disgust* and *happiness* more than the other emotions.

Red is one of the powerful colors, with its associations with passionate emotions such as love, blood, and fire.[14] Furthermore, it is the color that creates the highest number of emotional responses.[26] It is associated with surprise, happiness and sadness,[27] energy, vitality and power,[28] fear, and

anger.[29] Thus, red evokes emotions ranging from the negatives (anger, fear, and sadness) to positives (happiness, energy, and power).

The results of this study were similar as disgust and happiness were mostly associated with red. That shows the ironic side of this color. The fact that the red color has an ironic side makes inappropriate for use on all vertical surfaces of a space as it will create contrary feelings at the same time. Thus, it is critical that the use of red color should be balanced with regard to emotions at the same time. The number of participants who matched the red room with happiness were 20, and 14 of them found the red interior space to be active and energetic. On the other hand, the ones who associated the red room with disgust were 21, and 9 of them mentioned its discomforting side. Some expressions recorded after the experiments regarding participants' feelings of the association of disgust with the red room are as follows:

> "[…] I do not want to spent time in a space with red walls. It is a very powerful color, thus I think that after a while I may feel tired […]."

> "Red background can be disturbing especially while trying to focus on something."

> "[…] in my estimation, red color is more appropriate for leisure spaces, not for home."

> "The idea of red room is exciting."

The second experiment set involved the green room. The number of participants who matched the green room with *neutral* and *happiness* is larger than the other emotions. Disgust was also associated with green. The green room was thought to be neutral when it is first experienced. It is interesting to note that, when participants experienced the green room after the gray room, a large number thought that it was inducing happiness rather than being neutral. Neutral is being allocated to the gray room. Most of the participants who matched the green room with neutral wanted to change their response to happiness after seeing the gray room. They stated that, after seeing the gray room, they started to perceive the green room as a happier environment.

Similar to previous studies,[13] green was associated with the positive emotion of happiness and neutral. Of 15 participants who matched the neutral with the green room, 11 mentioned that they chose it as it represented calmness and relaxation more than the other facial expressions. Thus, neutral was thought to be an outcome of calmness and relaxation, being a rather positive state. On the other hand, in the instances where the green room was associated with disgust, participants indicated that the color green was their least favorite color.

The third experiment set covered the blue room. The number of participants who matched the blue room with *neutral* was larger than the other emotions. Of 25 participants who matched the blue room with neutral, 9 mentioned that it represented calmness, and 8 of them associated it with relaxation, similar to the green room, with neutral again being a rather positive state of emotion. Thus, the interpretation of neutral was different for gray and blue rooms. Participants matched the blue room with neutral because they felt that neutral had the most representative facial expressions for relaxation, calmness, and peacefulness. This was expected from the connotations of blue with infinity and serenity in relation to the sky and the sea, which represent peacefulness and relaxation.[15] In this study, participants who associated the room with negative emotions generally complained about the tone of the blue. They found its brightness and saturation values high.

In each experiment set, in addition to chromatic wall-colored rooms, the same interior space was also assessed with an achromatic wall color. The aim was to control the emotional reactions to chromatic wall-colored rooms. It was assumed that, if the approaches to the chromatic room and gray room were the same, then the hue (color) of a room was not asserting any emotions. However, emotional reactions for each chromatic room differed from achromatic spaces. Thus, hue (color) was found to affect emotions for a space significantly.

TABLE 5 Mostly associated emotions with gray room

	Emotions
Gray (first experiment set-red)	Disgust, neutral, sadness
Gray (second experiment set-green)	Disgust, neutral, sadness
Gray (third experiment set-blue)	Neutral, sadness, disgust

TABLE 6 Mostly associated emotions with chromatic rooms

Chromatic rooms	Emotions
Red room	Disgust, happiness
Green room	Neutral, happiness, disgust
Blue room	Neutral

TABLE 7 Mostly associated emotions with living rooms

Living rooms	Emotions						
	Anger	Disgust	Neutral	Surprise	Happiness	Fear	Sadness
Red room		■			■		
Green room					■		
Blue room			■				
Gray room		■	■				■

An achromatic wall color of gray, which did not have any hue in it, was assumed to be a neutral interior with no strong emotional associations. This study showed that, in isolation, the achromatic gray acted as a color (as in chromatic colors) in its own right. Gray was associated with neutral as expected, with participants having no feelings toward that color, but it was also associated with negative emotions such as disgust and sadness (Table 5). Chromatic colors were associated more with positive emotions as they were considered more active colors than gray (Table 6). Some participants' comments on gray room were:

> "It looks like somebody who is pessimistic is living here."

> "I hate it."

> "I do not feel anything towards that room."

From these perspectives, it is possible to report that users desire color in space in order to feel something or in order to create a psychological bond with it.

The effect of gender on color-emotion associations was also examined in this study. It was expected that female and male groups had different approaches to and associations with colors. Previous studies about individual differences in preferences of color supported that gender played an important role in the personal interpretation of color.[26,30] However, contrary to the literature, no gender differences were found in the emotional associations of colors.

Pile claims that a living room should be in color tones ranging from mildly warm to neutral.[14] Stronger tones should only be used in smaller areas or as accents. According to Pile, although the idea of a *red room*, *green room*, and *blue room* may seem attractive, they should be used in a situation where there are a number of living spaces available to give the occupants the opportunity of choosing between the alternatives.[14] According to Helen, in hospitals, blue walls have a calming effect.[31]However, in a cafe, the same color causes employees to complain about a cold environment. Thus, it is fundamental to become aware of the power of color and design built environments with respect for users' emotional and physiological health.

6 | CONCLUSION

Both emotion and color play a central role in peoples' lives. People are always experiencing these phenomenon consciously or unconsciously in their daily lives. These experiences affect people psychologically and physiologically; thus, color and emotion have an influence on the quality of our lives. Moreover, color as one of the major design tools supplies more legible interior spaces to people. With effective planning in the integration process of color and space, more sensitive and relevant designs may be achieved. These kinds of spaces become more user friendly, and they reduce the possible stress levels of users. Therefore, in a way, all these three important concepts—color, interior space, emotion—are related to each other.

Much research on the relationship between human emotions and color has been carried out.[27-29,32-34] However, none of these studies were conducted with any reference to interior space. Thus, there is not enough research dealing with the association of emotion and interior space, and there is also a lack of research combining both the concepts of color and emotion in the scope of interior design.

In order to understand more about color, future studies can focus on different colors. These approaches allow creating and improving a guideline for designers and interior architects that may be used as a dictionary to illustrate which color in interior space is associated with which specific emotion. In addition to testing different hues in future studies, the effects of different brightness and saturation levels of colors can be tested by keeping the hues constant. As the hue, brightness, and saturation are the three qualities of color that are important in explaining the "sensation" of color, their rates would make a difference in impressions about a particular color. In line with that, it was reported that positive emotions tended to be associated with greater brightness and more saturated colors, while negative emotions tended to associate with lower brightness.[35] However, in the current study, it is important to use the colors with the same brightness and saturation for controlling the variables. In order to

understand the effect of hue, brightness and saturation rates were kept the same.

A living space fulfills the need to belong as one has an opportunity to socialize with family and friends. It also provides a semipublic space where an interaction is possible. The same study could be repeated and tested with different kinds of spaces. For instance, the sleeping room could be tested as being a different kind of space. This would answer the physiological needs of sleeping, resting, and a private area for users. Moreover, spaces serve diverse functions such as dining or working; thus, cafes, restaurants, bars, and offices could also be examined with regard to the application of discrete colors in terms of their associations with emotions.

There were no gender differences in emotional association to any of the colors used. In this study, different demographics, such as age, education, and sociocultural factors, could be tested in future studies. In addition, this study was conducted with participants who do not have a design background in order to provide information to designers and researchers from the user's perspective. However, future studies could concentrate on obtaining information from participants with a design education to find the possibly different approaches.

It is claimed that a space generates favorable reactions if it presents a pleasant and proper impression with the use of color.[14] However, the same space will be depressing and disappointing with an unpleasant use of color. In order to form some design judgments on the use of color in spaces, it is utmost to experience color through exercises and planned experiments. In this study, the room with red walls was mostly associated with the emotions of disgust and happiness; the green room was mostly associated with happiness; the blue room was mostly associated with neutral; and the gray room was mostly associated with neutral, disgust and sadness, where neutral was also seen as a rather positive emotion with the facial expression resembling serenity and calmness (Table 7). All these results and the suggestions should be taken into account by architects, interior architects, designers, and researchers to create more pleasant and healthy spaces.

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ENDNOTES

[1] Veiling reflections occur when the incident light angle on the horizontal work surface is within the observer's viewing zone.[21]

[2] Reflectance is the percentage of light reradiated from a surface.[21]

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