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Effect of Wall Colors and Usage Rates on The Perception of Interior Spaces

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Highlights

- This paper focuses on the effects of colors and usage rates on the spatial perceptions of users.
- This study has the attribute of a new study about the effects on the spatial perceptions of users.
- Differences in the colors and usage rates were changing according to genders and professions.

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Abstract

In this study, it was aimed to determine the effects of colors and the usage rates in interior spaces on the spatial perceptions of users. With this objective, a living space was designed in a manner that would have three different colors (warm, neutral, and cool) and usage rates at 10%, 50%, and 100% and digital visuals were prepared. A total of 233 subjects participated in the research questionnaire and the data obtained were analyzed. In conclusion, it was determined that the living spaces which were colored at a low rate were perceived more positively according to the Semantic Differentiation Scales compared to the completely colored spaces. The spaces where warm and cool colors were used at the rate of 10% were perceived as more spacious and beautiful compared to the spaces where colors were used at the rates of 50% and 100%, whereas it was observed that when the values received were from positive to negative, they were listed in the form of 10% > 50% > 100%. Despite this, it was determined that the spaces where warm colors were used at the rates of 50% and 100% were perceived as more informal. Furthermore, it was observed that the differences in the colors used on the walls and the usage rates were changing according to gender and professions. Accordingly, it was determined that especially females and interior architects preferred, even more, the spaces with warm colors having a low usage rate.

1. INTRODUCTION

A large share of the interactions of humans with the environment is based on perceptions and behaviors. The perceptual performances of users shape the environmental factors of spaces. In the study by Baker [1], environmental factors were classified under the three main headings of environment, design, and social factors. The design factor included in this classification contains elements, such as color, texture, illumination, placement of equipment, and architectural plan. Whereas, within these environmental data, the use of color has a quite important place. Color has always been a part of architectural design and has affected users aesthetically, emotionally and perceptually. Designers apply colors primarily and easily for emphasizing the character and function of spaces and space atmosphere [2]. It is also known that every atmosphere created has psychological and behavioral influences on people who engage in activities in that living area. From this aspect, it would be beneficial to know what could happen in the color organizations that could assist in the positive perceptions of architectural spaces, that would meet the user needs at the optimum level.

The research studies made related to the psychological and physiological effects of colors focused on the effects on human psychology and physiology with only the color, value and satisfaction attributes of colors, independent from the spaces [3-5]. The studies in this group dwelled upon the psychological and physiological reactions, such as making inferences from the colors preferred when making paintings [6],

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determining the colors preferred connected to gender and age [7] and the use of colorful surfaces for visibility and legibility [8]. However, when only the different colors, values and satisfaction attributes of color are applied in spaces, the perceptual evaluation results that would be obtained would be different [9].

Whereas, spatial perception research studies focused on the determination of the differences among the research environments (real space, virtual space, augmented virtual reality space, etc.) [10], research questions/tasks (spatial quality evaluations, task definitions, measurement of physiological reactions, etc.) [11] spatial attributes (color, size of space, plan, etc.) [12-13] and user attributes (gender, age, profession, education, culture, spatial experience, etc.) [14-15]. In this group of studies, the functions of the spaces, sizes, design attributes, usage scenarios, and other variables are evaluated with the interaction of colors.

Whereas this study has focused on the determination of the effects on the spatial perceptions of users for color and the usage rates used in interior spaces. For this purpose, living spaces were designed where three different colors, warm, cold and neutral, are applied in different proportions. Users were asked to rate these digital images. In the evaluation of these digital images, three different scales were used as Cognitive Differentiation Scale, Emotional Differentiation Scale and Behavioral Differentiation Scale [16]. With the help of these scales, it will be tried to determine how the spatial quality of the living room is perceived by the users, how the users are affected emotionally and how their behavioral preferences develop. The limitations of the study and the survey design are explained in detail in the second title of the study. The conceptual framework treated with this objective and the research hypotheses formed have been given in detail below.

1.1. Conceptual Framework and Research Hypotheses

In the literature, that treats the subject of the effects of colors on spatial perception, it was reported that red is stimulating [12], exciting [17], that it increases the physiological reactions of users in the space [18] but it creates a tendency for stress and anxiety [19]. Whereas, the other colors that invite these attributes are warm colors, such as yellow and orange [17]. Blue and derivative cool colors have calming, happiness, quietness and peaceful reactions and are preferred in health buildings [20] in response to this, it is also expressed that they could create a tendency for depression in spaces [19]. Whereas, green used in housing spaces appears with the attributes of being safe/secure, the feeling of purity and dynamism [20]. It was expressed in some studies that a transition from cool colors towards warm colors is more effective in the physiological reactions of users [18], increases the quality and dynamism of spaces [16,21] and facilitates spatial recollection [22]. Besides these, it is expressed that spaces with cool colors are more directive [22] compared to spaces with warm colors. In a different study, it was seen that they were characterized by concepts such as spaciousness, openness, simplicity and regularity [23].

In another study, it was stated that the interaction of a color with other colors changes with the form of use, the dimension of use, and the effect of the color on the application place [24]. In the study by Li et al., [25] they set forth that it also changed according to the color combinations used together with the differences in color perception. Furthermore, it was determined that the spatial memory and the memorability of spaces where high color contrasts were used increased independently from the color [11].

Very limited studies have been conducted related to the color usage rates and size stimulation color. In the study by Xiao et al. [9] which examined in detail the effects on the color perception of the size of colored stimulants, they experimented via digital screens and through cardboard in a manner independent from the colored surface space. They reached the conclusion in the study that the colors were perceived as more vivid and clear in the size stimulation.

It was observed from all this literature, that the colors used in the space were effective on users and that different meanings were given to the colors by users. However, a study was not encountered that compared these effects and the perceptual evaluations of the colors with the usage rates in a space. Accordingly, it appears to be a great benefit scientifically to know whether the perceptual effect changes when it is repeated in different usage rates in a space with the same color. In this study made with this objective, it was targeted to set forth new findings in this field by determining the effects on the perceptual evaluations of users of

different usage rates for the same color in a space. The main hypothesis of this study was that connected to the change in the color usage rates used in interior spaces, the color perception of users could also change.

From this aspect, this study has the attribute of a new study about the effects on the spatial perceptions of users for three different color usage rates on interior space walls. According to these determinations, the research hypotheses formed connected to the variables of the colors and the usage rates used on interior space walls have been given below:

H1: There are different effects on the spatial perceptions of participants according to the color and the usage rates used on the walls in living spaces according to the Cognitive, Emotional and Behavioral Differentiation Scales.

H1a: The walls of spaces painted with completely warm colors are perceived as darker, narrower, and lower compared to spaces that have lower color usage rates.

H1b: The walls of spaces where colors are used at the rate of 10% and 50% are perceived as more positive according to the Emotional Differentiation Scale compared to spaces where colors are used at the rate of 100%.

H1c: The walls of spaces that are completely colored are perceived as more negative independently from the color according to the Behavioral Differentiation Scale compared to spaces colored at the rates of 10% and 50%.

H1d: Participants prefer to be in spaces where color is used regionally rather than to be in completely colored spaces.

Recently, the gender factor was included as a significant independent variable, for which its effect was researched in spatial perception studies. In one of the slight number of studies made on this subject, Memiş [26] by acting from the individual differences method, researched by using a psychophysical experimental mechanism of whether or not gender was effective on color perception and in conclusion reported that gender differences did not play an important role on the color perception in objective evaluations, however in scales and tasks based on subjective evaluations, females and males perceived and evaluated the spaces in different manners. In the study by Yıldırım et al. [27] they reported that males, perceived and evaluated more positively the wall colors used in a cafe according to the Semantic Differentiation Scale composed of adjective pairs compared to females. It was set forth in the study by Kwallek [28] that females who went from a blue-colored office to a red-colored office made more mistakes compared to males. Whereas, in a similar study made by Kwallek and Lewis [29] it was reported that an office using red or white colors was found to be more disturbing by males compared to females. Whereas offices using green colors were found to be more disturbing by females compared to males. In a study made by Jalil et al. [30] on color preference and perception for a hostel room, females selected pink in first place, whereas males selected blue in first place. Furthermore, females reported that they found blue and green colors to be more peaceful and calming compared to males. In a study by Çağatay et al. [31] it was reported that female university students preferred pink and orange colors on the walls of rooms, whereas males preferred blue and white colors.

The studies treated above showed that there were significant differences between genders in spatial color perceptions. According to these results, it can be thought that gender is an effective independent variable in the perception of space. According to these evaluations, the research hypothesis formed connected to gender variables has been given below:

H2: There are significant differences between the color preferences and the usage rates according to the gender of the participants.

Recently, the education and profession factors were included as important variables, whose effects were researched in spatial perception studies. It was set forth in some studies made, especially in fields, such as product design, space design and environmental design, that education would affect spatial perception. In

the study by Baniani and Yamamoto [14] that treated the relationship between color preference and design education in the duty of interior and exterior space painting, it was reported that individuals receiving art and design education used a larger number of colors in the painting duty, compared to others. In the study by Müezzinoğlu et al. [16] it was reported that individuals who did not receive design education perceived and evaluated more positively the spaces designed with chromatic (warm or cool) colors, whereas individuals who received design education perceived and evaluated more positively the spaces designed with cool colors. In the study researched by Li et al. [25] for the suitable color combinations for building façades, they determined that there were significant differences between the subjects who received professional education and who did not receive professional education. These results set forth that design education could affect spatial perception. Connected to the studies above that treated the effects on color perception of educations, the research hypothesis formed has been given below:

H3: To receive design education is the cause of differences among the preferences by participants in the color and the usage rates used in spaces.

The studies conducted in this field showed that there could be positive / negative effects on the spatial perceptions of users for the physical environmental factors, which are classified in the form of design, environment and social factors. However, it is necessary to limit the environmental variables in experimental studies for being able to determine completely the effects of the variable researched and for being able to set forth applicable principles by interpreting the results. Consequently, the independent variables of this research have been determined in the form of color, color usage rates, gender and profession. Environmental factors, such as illumination, equipment attributes and placement order, were kept constant in the design of the experimental space.

2. MATERIAL AND METHODS

2.1. Selection of Participants

This study was conducted to determine the effects on the spatial perceptions of participants for the colors and the usage rates used in living spaces. A total of 235 students participated, with 143 females and 92 males, who receive education at the Selçuk University in Konya, Turkey. Two participants, who were determined to be color blind, were excluded from the questionnaire evaluation. The participants were composed of interior architecture department students receiving design education, and law department students not receiving design education. The numbers of participants according to department, gender and year of education have been given in Table 1.

Table 1. *General attributes of the participants*

Year	Students Receiving Design Education (Interior Architecture)			Students Not Receiving Design Education (Law)		
	Female	Male	Total	Female	Male	Total
1st Year	14	10	24	15	16	31
2nd Year	21	12	33	14	10	24
3rd Year	27	11	38	12	13	25
4th Year	20	8	28	20	10	30
Total		123			110	

2.2. Design of Questionnaire

Place was given to three groups in the questionnaire form constituted for evaluating the accuracy of the hypotheses treated in the study. In the first section, there are questions included on the personal information related to the participants, such as gender, age, department and year of study. In the second section, there are questions for evaluating the “cognitive”, “emotional,” and “behavioral” reactions of the users for colors (Warm, Cool, Neutral) and the color usage rates (10%, 50%, 100%). Whereas, in the third section, there are questions formed for determining the preferences of being in the space by users for different colors and usage rates. In the evaluation of the colors and the usage rate in the space, the Semantic Differential Scale

was used that was separated into three sections composed of the seven-staged adjective pairs (1: positive, 7: negative) listed from positive to negative conducted previously in the perception studies found to be valid and reliable by Ertürk [32], Yıldırım et al. [33], and Hidayetoğlu et al. [22], and Müezzinoğlu et al. [34]. These were determined for the Cognitive Differentiation Scale as warm / cool, light / dark, high / low, broad / narrow, and symmetrical / asymmetrical; for the Emotional Differentiation Scale as beautiful / ugly, spacious / cramped, stimulating / drowsy, informal / formal; for the Behavioral Differentiation Scale as open to creativity / closed to creativity, motivating / boring, provides concentration / distracts concentration, facilitates communication / prevents communication.

2.3. Design of Space

The living space (living room) was selected as the research setting where an important part of the daily life of users is spent and experienced for determining the effects on users of the colors and the usage rates. The research setting was designed, and realistic images were rendered in the 3Ds Max program by keeping under control all the environmental factors for performing this experimental study in a sound manner. Thanks to this, they can be compared by designing economical, rapid, and controllable digital spaces. In many studies in the literature, measurements were conducted in virtual environments connected to the space experiences of users [12, 17, 22, 35, 36]. In many studies, it was expressed that the data obtained from real spaces displayed a parallelness with the digital environments and that the real environments can be simulated by digital spaces [37-40].

In the living space designed digitally, realistic images were rendered in a manner where the two walls that intersect each other could be viewed completely and with a double point perspective viewpoint. The designed experiment space has a square plan of 6 x 6 meters and the ceiling height is 2.8 meters. The color usage rates that would be evaluated were designed in a manner that was regional (10%), half (50%) and complete (100%) by considering panels, which constitute the walls (Figure 1). In regional (10%) and semi-colored (50%) spaces, experimental colors were used on the right side of the space to curtaining as much as possible by the equipment and accessories. In the selection of the wall surfaces of the experimental spaces, the widespread use of color types with significant saturation on the walls in interior design was effective.

10% usage rate 50% usage rate 100% usage rate

Figure 1. *The virtual spaces and the color usage rates used in the experiment*

All the physical conditions (chair, sofa, table, plants, etc.), other than the colors and the usage rates on the walls of the living space designed, were constant.

2.4. Selection of Colors

A pre-questionnaire was conducted for determining the colors and the usage rates that would be used on the walls of the experimental spaces. Warm, cool, and neutral colors were used, which were used previously in the studies made by Hidayetoğlu et al. [22], Yıldırım et al. [12,33], Çağatay et al. [31], and Müezzinoğlu et al. [16], in the determination of the colors included in the pre-questionnaire. It was requested from the participants that they select "the warmest, the coolest, and the most neutral" colors of the 20 colors found in the questionnaire. A total of 325 students participated in the online questionnaire for the selection of the colors that would be used in the experiment. The following were selected at the conclusion of the questionnaire: the warmest color at the ratio of 32.8% was the red (RGB: 177,38,33 / CIELab; L:40, a:55, b:40) used in the study by Yıldırım et al. [12], the coolest color at the ratio of 19.7% was the blue (RGB:

198,226,255 / CIELab; L:89, a:-5, b:-17) used in the study by Müezzinoğlu et al. [16], and the most neutral color at the ratio of 23.6% was the beige (RGB: 214,209,192 / CIELab; L:84, a:0, b:9) used in the study by Çağatay et al. [31].

2.5. Application of Experiments and Procedure

A total of 233 students participated in the research questionnaire who were receiving education at the Selçuk University, Department of Interior Architecture and Environmental Design and the Department of Law. The face-to-face questionnaires made in groups in the same order were completed in a period of approximately 30 days. The period of completing the questionnaire for each participatory group was approximately 20 minutes. The experiment conducted was composed of two stages. In the first stage, information was given to the participatory groups for approximately 10 minutes. Subsequently, the images of the different usage rates (10%, 50%,100%) for the warm, neutral, and cool colors used in the virtual spaces were high-quality colored questionnaire printouts were distributed to the participants. Furthermore, to control the survey process, the images also reflected to a movie screen with a movie projector. Thus, by increasing the visual opportunities, it was attempted to provide for the participants to give realistic answers. The effects of the warm, neutral, and cool colored spaces on the perceptual evaluations of the participants were evaluated with the Semantic Differentiation Scale. In the second stage of the experiment, the space visuals evaluated by the participants in the previous section were given as a whole and it was requested that they number in order the three spaces in which they would want / prefer the most to live from the nine visuals. The digital space visuals prepared for the experiment have been given in Figure 2.

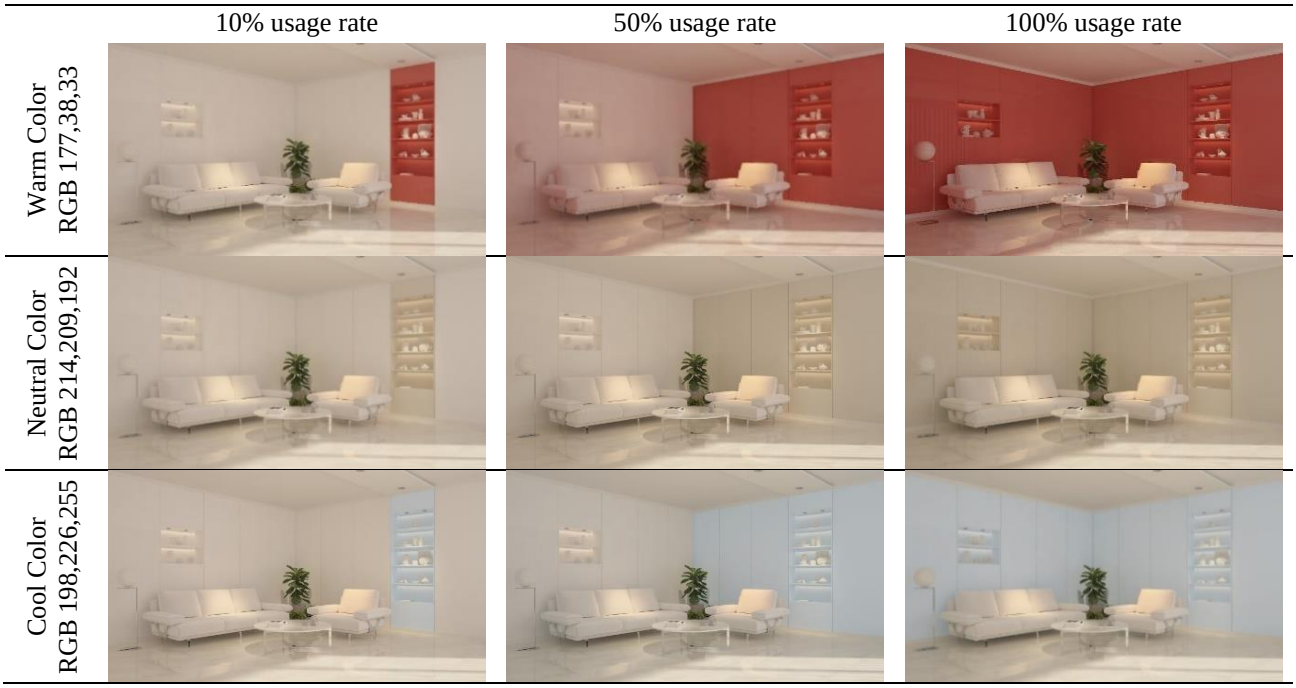


Figure 2. *The colors and the usage rates used in the virtual experimental spaces*

2.6. Statistical Analysis

In this research, participants' spatial perceptions of the environmental factors of living spaces were accepted as dependent variables. Of the factors affecting perception, colors (warm, neutral, and cool), gender (female and male), and professions (interior architecture student and law student) were accepted as independent variables. Uttley's [41] work was used in the research model and statistical tests. The model for testing the research hypotheses was composed in the form of a 3 x 2 x 2 chart (color x gender x profession). After conducting reliability tests of the data obtained with the Cronbach's Alpha method, the mean and standard deviation values were determined. Subsequently, the techniques of the Multivariate Analysis of Variance (MANOVA), One-way Analysis of Variance (ANOVA) and Chi-Square tests were used to examine the effect of differences in color, gender, and profession variables on perceptions of physical environmental

factors in the living spaces. The mean values of the variables found significant in the analysis of variance were given in graphs.

3. RESULTS

It was aimed in this study to obtain information for designing high-quality spaces with a high level of perceptibility for designers and to research the cognitive, emotional, and behavioral evaluations of users for the colors and the usage rates in interior spaces. The findings obtained in the study have been given in order below.

3.1. Reliability Test

Reliability is one of the attributes questioned in measurement applications and expresses correlation between parallel measurements. In this sense, the Cronbach's Alpha coefficient is a test that gives information, and which is known as a proof of reliability [42]. The Cronbach's Alpha reliability tests were conducted on the data related to the dependent variables used in this study and the values have been given in Table 2. In the studies conducted by Cronbach [43], Panayides [44], and Yıldırım et al. [45], they reported that when the alpha coefficient is above 0.70, then the scale can be accepted to be "reliable".

Table 2. *Cronbach's Alpha reliability analysis results*

Scale Groups and Adjective Pairs	In-group Reliability Coefficient	Reliability Coefficient of the Scale
Cognitive Differentiation Scale Warm / Cool, Light / Dark, High / Low, Broad / Narrow, Symmetrical / Asymmetrical	0.825	0.914
Emotional Differentiation Scale Beautiful / Ugly, Spacious / Cramped, Stimulating / Drowsy, Informal / Formal	0.778	
Behavioral Differentiation Scale Open to Creativity / Closed to Creativity, Motivating / Boring, Provides Concentration / Distracts Concentration, Facilitates Communication / Prevents Communication	0.853	

When the reliability coefficients given in Table 2 are examined in detail, it is observed that the coefficient of the Cognitive Differentiation Scale is 0.825, the coefficient of the Emotional Differentiation Scale is 0.778 and the coefficient of the Behavioral Differentiation Scale is 0.853. Whereas the main scale reliability coefficient is 0.914. Since these Alpha coefficients were above 0.70, it was accepted that they are "reliable".

3.2. Comparison Tests

In the research, firstly, the effects of interactions among independent variables (color, gender, and profession) depending on participants' spatial perceptions of physical environmental factors for the dependent variables were tested using the MANOVA, and the results were given in Table 3.

Table 3. *MANOVA of the independent variables*

Independent Variables	**F**	**df**	**Sig.**	**Results**
Color	9.083	39	0.000*	p<0.05
Gender	2.743	78	0.000*	p<0.05
Profession	2.629	39	0.000*	p<0.05
Color x Gender	1.067	78	0.329	is
Color x Profession	1.203	78	0.115	is
Gender x Profession	1.475	39	0.034	p<0.05
Color x Gender x Profession	0.752	78	0.946	is

Notes: F: F value, df: Degree of freedom, Sig.: Significance. * p<0.05 is the level of significance, is: Insignificant.

According to the results given in Table 3, the main effects of "color", "gender", and "profession" with the effect of the "gender x profession" two-way interaction were found to be significant at a level of $p<0.05$. On the other hand, the effects of the other two-way interactions and three-way interaction were found to be insignificant.

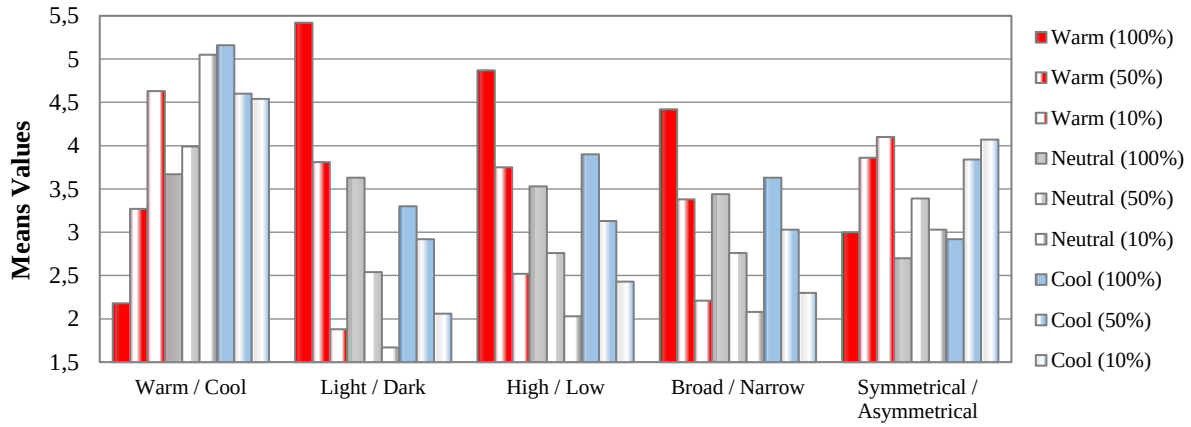
In this part of the research, the effects on the spatial perceptions of participants to the three different color (warm, neutral, and cool) and usage rates (10%, 50%, and 100%) used on the walls in the living space were tested by using the Cognitive, Emotional and Behavioral Differentiation Scales. First, the data, mean and standard deviation values, the Tukey's Honestly Significant Difference (HSD) and ANOVA test results obtained related to the effects on the spatial perceptions of the participants according to the Cognitive Differentiation Scale of the environmental factors for the experimental spaces have been given in Table 4.

Table 4. *Means, standard deviation, homogeneity and analysis of variance of the dependent variables for the colors and the usage rates according to the Cognitive Differentiation Scale*

Cognitive Differentiation Scale		**Space Colors**									**ANOVA Results**		
		Warm Color			Neutral Color			Cool Color					
		M[a]	SD	HG	M	SD	HG	M	SD	HG	F	df	Sig.
Warm / Cool	100%	2.18	1.82	A	3.67	1.99	B	5.16	2.12	C	132.358	2	0.000*
	50%	3.27	1.29	A	3.99	1.66	B	4.60	1.61	C	44.190	2	0.000*
	10%	4.63	1.68	A	5.05	1.91	B	4.54	1.94	A	4.993	2	0.007*
Light / Dark	100%	5.42	1.48	B	3.63	1.77	A	3.30	1.79	A	106.394	2	0.000*
	50%	3.81	1.28	C	2.54	1.29	A	2.92	1.42	B	56.189	2	0.000*
	10%	1.88	1.45	AB	1.67	1.34	A	2.06	1.40	B	4.533	2	0.011*
High / Low	100%	4.87	1.66	B	3.53	1.67	A	3.90	1.78	A	38.462	2	0.000*
	50%	3.75	1.24	C	2.76	1.37	A	3.13	1.42	B	31.719	2	0.000*
	10%	2.52	1.58	B	2.03	1.42	A	2.43	1.60	B	6.615	2	0.001*
Broad / Narrow	100%	4.42	1.74	B	3.44	1.77	A	3.63	3.63	A	19.916	2	0.000*
	50%	3.38	1.38	B	2.76	1.46	A	3.03	1.43	A	11.202	2	0.000*
	10%	2.21	1.50	A	2.08	1.54	A	2.30	1.49	A	1.280	2	0.279is
Symmetrical / Asymmetrical	100%	3.00	1.84	A	2.70	1.66	A	2.92	1.77	A	1.817	2	0.163is
	50%	3.86	1.93	B	3.39	1.78	A	3.84	2.01	B	4.417	2	0.012*
	10%	4.10	1.91	B	3.03	1.94	A	4.07	1.85	B	23.744	2	0.000*

Notes: *p<0.05 is the level of significance. is: Insignificant. M: Mean value, SD: Standard deviation, HG: Homogeneity group, F: F value, df: Degree of freedom, Sig.: Significance. [a] Variable means ranged from 1 to 7, with higher numbers representing more negative responses.

According to the results given in Table 4, the differences among the spatial perceptions of students according to the Cognitive Differentiation Scale for the environmental factors of the living spaces having three different colors and the usage rates were found to be statistically significant at the level of $p>0.05$ for the adjective pairs of warm / cool (100% and 50%, p=0.000; 10%, p=0.007) for light / dark (100% and 50%, p=0.000; 10%, p=0.011), for high / low (100% and 50%, p=0.000; 10%, p=0.001), for broad / narrow (100% and 50%, p=0.000), and for symmetrical /asymmetrical (50%, p=0.012 and 10%, p=0.000) adjective pairs. However, a statistically significant difference was not found at the level of $p<0.05$ at (10%=0.279) for broad / narrow and at (100%, p=0.163) for symmetrical / asymmetrical adjective pairs. These results showed that there were significant effects on the spatial perceptions of the participants according to the Cognitive Differentiation Scale for the colors and the usage rate on walls. The graphic expression of these results has been given in Figure 3.



Note: Means of the variables listed between 1-7 (large numbers are negative responses).

Figure 3. *The effect of colors and the usage rates on dependent variables according to the Cognitive Differentiation Scale*

According to Figure 3, it was observed that the neutral-colored spaces and the 100% warm and 100% cool colored spaces were perceived to be more symmetrical. These results showed that the color used in the experimental space and the color usage rates had significant effects on the spatial perceptions of the participants according to the Cognitive Differentiation Scale. This result has the attribute of supporting the hypothesis set forth in the **H1** hypothesis, *"There are different effects on the spatial perceptions of participants according to the colors and the usage rates used on the walls in living spaces according to the Cognitive, Emotional and Behavioral Differentiation Scales."*

In another result, the spaces where warm, neutral, and cool colors were used at the rate of 10% were perceived as lighter, higher, and broader compared to the spaces where colors were used at the rates of 50% and 100%. Whereas, when the values were taken from positive to negative, it was observed that they were listed in the form of 10% > 50% > 100%. Furthermore, the spaces where the warm color was used at the rate of 100%, which is perceived to be warmer, it was perceived as darker, lower and narrower compared to the space with neutral and cool colors. These results have the attribute of supporting the hypothesis set forth in the **H1a** hypothesis, "*The walls of spaces painted with completely warm colors are perceived as darker, narrower, and lower compared to spaces that have lower color usage rates.*" When the results are considered in general, spaces using the neutral color were perceived to be more symmetrical. Furthermore, it was observed that as the rates of the neutral and cool color usage decreased, the spaces were perceived to be lighter, higher, and broader and as the usage rate of cool colors increased, the spaces were perceived to be cooler and more symmetrical.

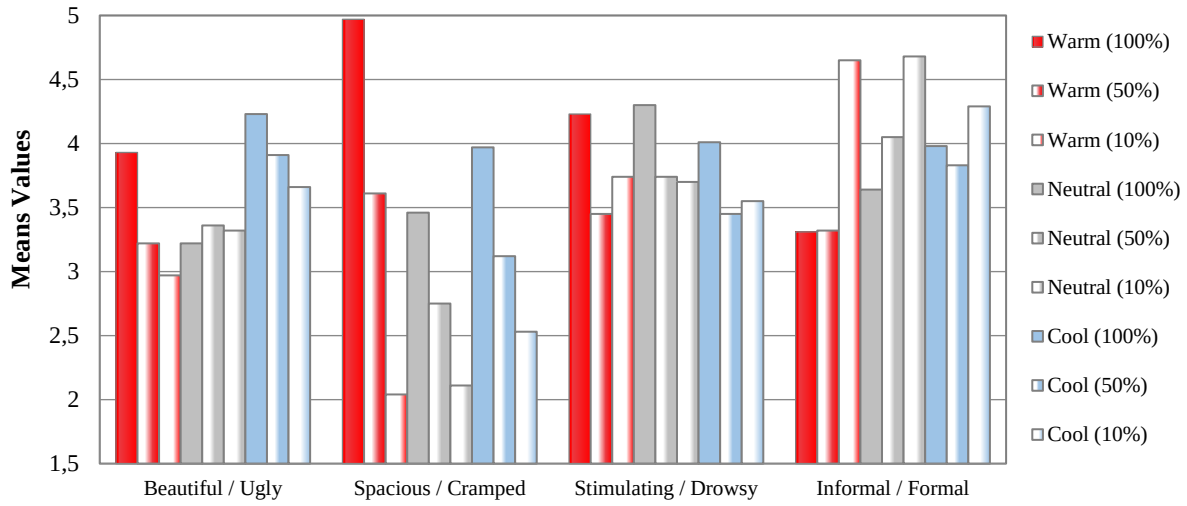
The data, mean and standard deviation values, the Tukey's HSD and ANOVA test results obtained related to the effects on the spatial perceptions of the participants according to the Emotional Differentiation Scale for the experimental spaces have been given in Table 5.

According to the results given in Table 5, statistically significant differences were found among the spatial perceptions of participants according to the Emotional Differentiation Scale for the environmental factors of living spaces having three different colors and the usage rates at the levels of $p<0.05$ and $p<0.10$ for the adjective pairs of beautiful / ugly (100%, 50% and 10%, p=0.000), spacious / cramped (100%, 50% and 10%, p=0.000), stimulating / drowsy (50%, p=0.076), and informal / formal (100%, p=0.001, 50%, p=0.000, and 10%, p=0.054). However, a statistically significant difference was not found at the level of $p<0.05$ for the adjective pair of stimulating / drowsy (100%, p=0.269, and 10%, p=0.532). These results showed that there were significant effects on the spatial perceptions of participants according to the Emotional Differentiation Scale for colors and the usage rates. The graphic expression of these results has been given in Figure 4.

Table 5. *Means, standard deviation, homogeneity and analysis of variance of the dependent variables for the colors and the usage rates according to the Emotional Differentiation Scale*

Emotional Differentiation Scale		**Space Colors**									**ANOVA Results**		
		Warm Color			Neutral Color			Cool Color					
		M[a]	SD	HG	M	SD	HG	M	SD	HG	F	df	Sig.
Beautiful / Ugly	100%	3.93	2.04	B	3.22	1.86	A	4.23	2.23	B	14.741	2	0.000*
	50%	3.22	1.70	A	3.36	1.71	A	3.91	1.94	B	9.862	2	0.000*
	10%	2.97	1.64	A	3.32	1.85	AB	3.66	1.96	B	8.177	2	0.000*
Spacious / Cramped	100%	4.97	1.77	C	3.46	1.83	A	3.97	2.02	B	39.350	2	0.000*
	50%	3.61	1.43	C	2.75	1.50	A	3.12	1.62	B	18.849	2	0.000*
	10%	2.04	1.45	A	2.11	1.64	A	2.53	1.64	B	6.424	2	0.002*
Stimulating / Drowsy	100%	4.23	2.23	A	4.30	1.67	A	4.01	1.96	A	1.314	2	0.269is
	50%	3.45	1.47	A	3.74	1.67	A	3.45	1.65	A	2.587	2	0.076**
	10%	3.74	1.80	A	3.70	2.03	A	3.55	1.86	A	.633	2	0.532is
Informal / Formal	100%	3.31	1.90	A	3.64	1.88	AB	3.98	1.96	B	7.132	2	0.001*
	50%	3.32	1.43	A	4.05	1.77	B	3.83	1.69	B	12.078	2	0.000*
	10%	4.65	1.87	A	4.68	1.95	A	4.29	1.93	A	2.927	2	0.054*

Notes: *p< 0.05 and **p<0.10 are the levels of significance. is: Insignificant.
M: Mean value, SD: Standard deviation, HG: Homogeneity group, F: F value, df: Degree of freedom, Sig.: Significance.
[a] Variable means ranged from 1 to 7, with higher numbers representing more negative responses.



Note: Means of the variables listed between 1-7 (large numbers are negative responses).

Figure 4. *The effect of colors and the usage rates on dependent variables according to the Emotional Differentiation Scale*

According to Figure 4, the spaces where the warm and cool colors were used at a rate of 10% were perceived as more spacious and beautiful compared to the spaces where colors were used at the rates of 50% and 100%. Whereas it was observed that the values from positive to negative were listed in the form of 10% > 50% > 100%. Furthermore, it was found that the spaces where warm colors were used at the rates of 50% and 100% were more informal, whereas the spaces where warm colors were used at the rate of 100% were found to be much more cramped. On the other hand, it was observed that the spaces where blue color was used at the rate of 100% was found to be uglier, whereas the spaces where warm and neutral colors were used at the rate of 10% were found to be formal. Additionally, it was observed that the spaces where the warm, neutral, and cool colors were used at the rate of 100% were found to be drowsier. According to these results, it can be stated that the colors and the usage rate used in spaces has significant effects on the spatial perceptions of participants according to the Emotional Differentiation Scale. This result was found to have

the attribute of supporting the hypothesis set forth in the **H1b** hypothesis, *"The walls of spaces where colors are used at the rate of 10% and 50% are perceived as more positive according to the Emotional Differentiation Scale compared to spaces where colors are used at the rate of 100%."* When these results are considered in general, it was observed that the spaces which use warm, neutral, and cool colors at the rate of 10% were perceived to be more beautiful, spacious, and stimulating. Furthermore, it was observed that the spaces where warm colors were used at the rates of 50% and 100% were perceived to be more informal.

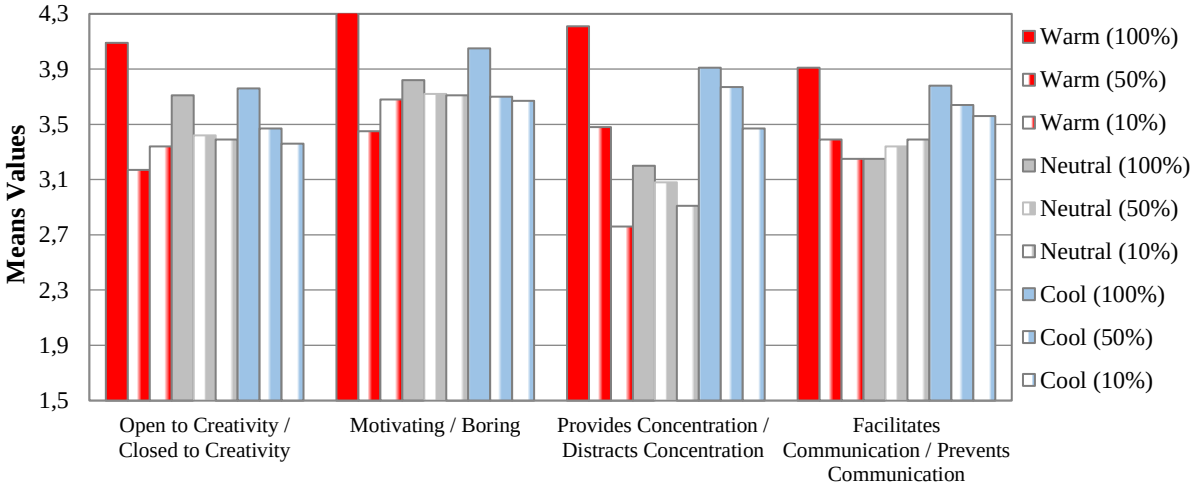
In another result, the data, mean, and standard deviation values, the Tukey's HSD and ANOVA test results obtained related to the effects on the spatial perceptions of the participants according to the Behavioral Differentiation Scale for the environmental factors of the experimental spaces have been given in Table 6.

Table 6. *Means, standard deviation, homogeneity and analysis of variance of the dependent variables for the colors and the usage rates according to the Behavioral Differentiation Scale*

Behavioral Differentiation Scale		**Space Colors**									**ANOVA Results**		
		Warm Color			Neutral Color			Cool Color					
		M[a]	SD	HG	M	SD	HG	M	SD	HG	F	df	Sig.
Open to Creativity / Closed to Creativity	100%	4.09	1.98	A	3.71	1.88	A	3.76	1.99	A	2.654	2	0.071**
	50%	3.17	1.63	A	3.42	1.69	A	3.47	1.76	A	2.190	2	0.113is
	10%	3.34	1.96	A	3.39	2.04	A	3.36	1.93	A	0.041	2	0.960is
Motivating / Boring	100%	4.31	1.93	B	3.82	1.82	A	4.05	2.04	AB	3.737	2	0.024*
	50%	3.45	1.60	A	3.72	1.66	A	3.70	1.74	A	1.802	2	0.166is
	10%	3.68	1.81	A	3.71	1.91	A	3.67	1.93	A	0.034	2	0.967is
Provides Concentration / Distracts Concentration	100%	4.21	1.90	B	3.20	1.72	A	3.91	1.94	B	18.003	2	0.000*
	50%	3.48	1.65	B	3.08	1.54	A	3.77	1.74	B	10.389	2	0.000*
	10%	2.76	1.71	B	2.91	1.78	A	3.47	1.85	A	10.379	2	0.000*
Facilitates Communication / Prevents Communication	100%	3.91	1.92	B	3.25	1.74	A	3.78	1.99	B	7.937	2	0.000*
	50%	3.39	1.46	A	3.34	1.56	A	3.64	1.71	A	2.418	2	0.090**
	10%	3.25	1.78	A	3.39	1.77	A	3.56	1.75	A	1.786	2	0.168is

Notes: *p< 0.05 and **p<0.10 are the levels of significance. is: Insignificant.
M: Mean value, SD: Standard deviation, HG: Homogeneity group, F: F value, df: Degree of freedom, Sig.: Significance.
[a] Variable means ranged from 1 to 7, with higher numbers representing more negative responses.

According to the results given in Table 6, statistically significant differences were found among the spatial perceptions of participants according to the Behavioral Differentiation Scale for the environmental factors of living spaces having three different colors and the usage rates at the levels of $p<0.05$ and $p<0.10$ for the adjective pairs of open to creativity / closed to creativity (100%, p=0.071), motivating / boring (100%, p=0.024), provides concentration / distracts concentration (100%, 50% and 10%, p=0.000), and facilitates communication / prevents communication (100%, p=0.076; 50%, p=0.090). However, a statistically significant difference was not found at the level of $p<0.05$ for the adjective pairs of open to creativity / closed to creativity (50%, p=0.113 and 10%, p=0.960), motivating / boring (50%, p=0.166 and 10%, p=0.967), and for facilitates communication / prevents communication (10%, p=0.168). These results showed that there were significant effects on the spatial perceptions of participants according to the Behavioral Differentiation Scale for the colors and the usage rate. The graphic expression of these results has been given in Figure 5.



Note: Means of the variables listed between 1-7 (large numbers are negative responses).

Figure 5. *The effect of colors and the usage rates on dependent variables according to the Behavioral Differentiation Scale*

According to Figure 5, it was observed that the spaces where warm and cool colors were used at the rate of 100% were perceived as closed to creativity, boring, distracts concentration, and prevents communication; the spaces where warm and neutral colors were used at the rate of 10% were perceived as provides concentration; the spaces where warm, cool, and neutral colors were used at the rates of 10% and 50% were perceived as open to creativity, and motivating; and the spaces where warm and neutral colors were used at the rates of 10% and 50% were perceived as facilitates communication, Whereas, in a general evaluation, it was determined that the spaces that were completely colored were evaluated negatively for every color compared to spaces colored at the rates of 10% and 50%. This result has the attribute of supporting for all adjective pairs the hypothesis set forth in the **H1c** hypothesis, *"The walls of spaces that are completely colored are perceived as more negative independently from the color according to the Behavioral Differentiation Scale compared to spaces colored at the rates of 10% and 50%."*

When the results obtained from the Cognitive (Table 4), Emotional (Table 5), and Behavioral (Table 6) Differentiation Scales, which were treated above, are considered, it set forth that both the colors and the usage rates of these colors were perceived in different manners by the participants. These results support the **H1** hypothesis.

Furthermore, it is thought that the colors and the usage rates used in the living space could also be effective on space preferences connected to the gender and professional situations of participants. Acting from this thought, in the final part of the research, the space preferences of participants were treated according to genders and professions. Accordingly, a total of nine digital images having three different color (warm, neutral, and cool) and usage rates (10%, 50%, and 100%) used on the walls in virtual living spaces were shown to participants and it was requested for them to prefer the space in which they would like to live the most. When the results of the preferences determined are considered, the space preferences according to genders have been given in Figure 6, whereas the space preferences according to professions have been given in Figure 7.

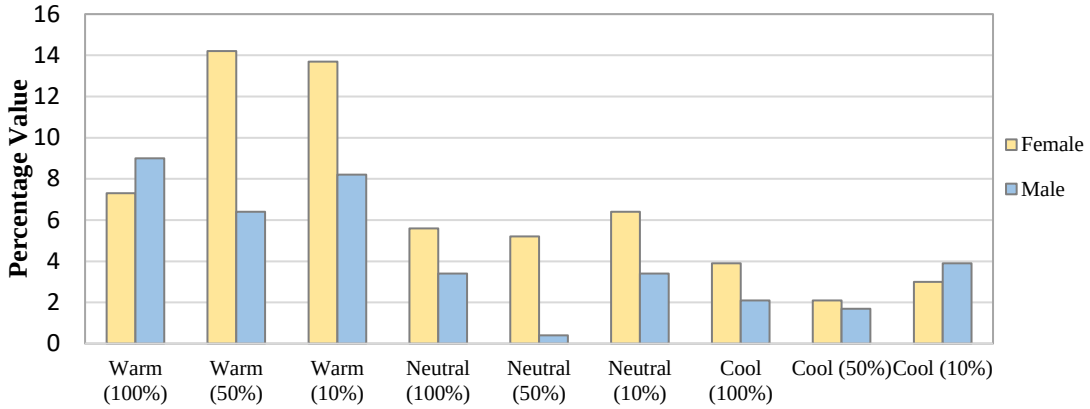


Figure 6. *Living space preferences according to genders*

It was observed in Figure 6 that the space preferences of participants showed a difference according to genders. It was tested with the Pearson's Chi-squared Test for whether the differences among the preferences were statistically significant or not according to the genders of the participants. According to the results of the Chi-squared test, statistically significant differences were found at the level of $p<0.10$ among the space preferences of participants (*Pearson's Chi-squared value: 13.247, df: 8, Sig. 0.102*). Accordingly, it was observed that 13.7% (32 persons) of the females preferred the walls where the warm colors were used at the rate of 10% and 14.2% (33 persons) preferred the spaces where the warm colors were used at the rate of 50%. A total of 8.2% (19 persons) of the males preferred the walls where the warm colors were used at the rate of 10% and 6.4% (15 persons) preferred the walls of the spaces where the warm color was used at the rate of 50%. Furthermore, it was observed that the spaces where the cool colors were used on the walls at the rates of 50% and 100% were preferred less. According to the results that appeared, it was observed that females preferred more the spaces where the warm and neutral colors were used at the rates of 10% and 50%. This situation supports the hypothesis set forth in the **H2** hypothesis, *"There are significant differences between the color preferences and the usage rates according to the gender of the participants."* These results showed that the differences in the colors used and usage rates on interior space walls are effective in preferences according to genders.

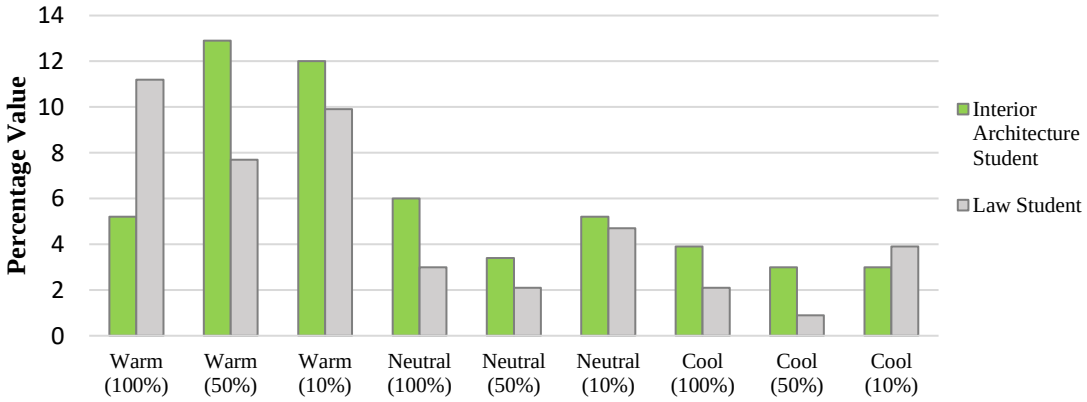


Figure 7. *Living space preferences according to the professions of participants*

It was observed in Figure 7 that differences were shown in the space preferences of the participants according to professions. It was tested with the Pearson's Chi-squared Test for whether the differences among the preferences were statistically significant or not according to the professions of the participants. According to the results of the Chi-squared test, statistically significant differences were found at the level of $p<0.05$ among the space preferences of participants (*Pearson's Chi-squared value: 15.210, df: 8, Sig. 0.054*). Accordingly, it was observed that 12% (28 persons) of the interior architecture students preferred spaces where warm colors were used on the walls at the rate of 10% and 12.9% (30 persons) preferred spaces where the warm colors were used on the walls at the rate of 50% and that 9.9% (23 persons) of the law students preferred spaces where the warm colors were used on the walls at the rate of 10%, and that

7.7% (18 persons) preferred spaces where the warm color was used on the walls at the rate of 50%. Additionally, it was observed that of the law students, 11.2% (26 persons) preferred the spaces where the 100% warm color was used on the walls. Furthermore, it was observed that the spaces where neutral and cool colors were used in the rates of 50% and 100% were preferred less. This situation supports the hypothesis set forth in the **H3** hypothesis, *"To receive design education is the cause of differences among the preferences by participants in the colors and the usage rates used in spaces."* These results showed that the differences in the colors used on inner space walls and the usage rates were effective in preferences according to professions.

When the results given in Figures 6 and 7 were considered in general, it was observed that the space that came into the forefront was the space where the walls had warm colors at the rate of 10%. Regional colored spaces at the rate of 10% for all colors were preferred even more compared to completely colored spaces. This situation supports the hypothesis set forth in the **H1d** hypothesis, *"Participants prefer to be in spaces where color is used regionally rather that to be in completely colored spaces."* According to the results, it was set forth that the color usage rates affected the preference of being in a space.

4. CONCLUSION AND SUGGESTIONS

While a great majority of the studies conducted related to the perception of color in spaces have determined the effects of colors in spaces, they have focused on the differences among colors. Whereas in contrast to the literature, this study has conducted comparative research related to the usage rates of color in spaces. It was researched in the study whether the spatial perceptions of users changes or not when different usage rates of the same color are applied. The results, which were obtained by benefiting from digital spaces, which were organized with three different colors and three different usage rates, has been treated systematically below.

The effects on the spatial perceptions of participants for three different colors (warm, neutral, and cool) and usage rates (10%, 50%, and 100%) used on the walls of a living space were determined according to the Cognitive Differentiation Scale. The conclusion was reached that of these spaces, especially the spaces where cool colors were used were perceived as cooler and lighter, the spaces where neutral colors were used were perceived as symmetrical and high, whereas the spaces where warm colors were used were perceived as warm and narrower. These results are compatible with the literature results [10,22]. In this study, which brought newness to the literature, it was set forth that color rates used in spaces have significant effects on user evaluations. Accordingly, spaces having a low color usage rate (10%) were evaluated as higher, broader, and lighter compared to spaces having a high color usage rate (50% and 100%). Furthermore, it was determined that as the color rates changed for every color, the cognitive evaluations of the participants also changed to a significant extent. According to these data, it can be stated that the use of regional color could be evaluated more positively by users in the perceptual organizations related to dimensions of the space and balanced appearance. Especially, it is envisaged that the use of warm colors in the entire space would limit to a significant degree the volumetric potential of the space. This result, as it was stated in the study by Mehta and Zhu [46], can be explained by the fact that the red color applied to the surroundings or surfaces is even more stimulating due to having an even longer wavelength.

The spatial perceptions of the users for the three different colors and the usage rates were determined according to the Emotional Differentiation Scale. It was observed that the participants evaluated differently the adjective pairs of beautiful / ugly, spacious / cramped, stimulating /drowsy, informal / formal according to the colors and the usage rates. When these results are considered in general, it was observed that the spaces where the warm, neutral, and cool colors were used at the rate of 10% were perceived to be more beautiful, spacious, and stimulating; furthermore, the spaces where the warm colors were used at the rates of 50% and 100% were perceived to be more informal. When the colors were taken into consideration, the data obtained showed a parallelness with the study by Güneş and Olguntürk [47]. These data set forth the necessity of making organizations at the color rates according to the emotional situation desired to be found by the users connected to the space function. For example, for warm, informal environments, intensive, warm colors could be used or for spacious and stimulating spaces, the amount of colored surface used could be decreased.

The spatial perceptions of the users for the three different colors and the usage rates were determined according to the Behavioral Differentiation Scale. In general, the participants gave more negative responses to this scale. This situation could be related to the function of the space. From these results, it is understood that the adjectives used in the Behavioral Differentiation Scale could be more meaningful for work [33] or education [16,22] environments. Similarly, in the study by Ulusoy et al. [48] the users set forth that there could be different color preferences for different space functions. However, it was also determined that the spaces colored completely were evaluated negatively for every color compared to spaces colored at the rates of 10% and 50%. Especially, in situations where the warm color is completely dominant in the space, it can be stated that the positive effects known about warm colors could be perceived in exactly the opposite direction.

The effect on space preferences of the colors and the usage rates used in living spaces were determined connected to the genders and professions of the participants. A great majority of the participants preferred warm colored spaces. However, despite this, it was observed that especially when color rates were taken into consideration, the spaces organized with a completely warm color were preferred less. This situation sets forth the conclusion that especially it could be more suitable to use warm colors regionally in spaces. In the results related to professional groups, it was set forth that especially the preferences of the participants who had received design education were different than the participants who did not receive design education. This result displayed a parallelness with the studies [16,19,22] that set forth that because of the design education, the users would be more critical in their space perceptions. Similar results also emerged in the study by Jiang et al. [15] related to the preference of furniture colors. Whereas, when the data related to gender and education were evaluated together, it was set forth that the participants, rather than being in completely colored spaces, preferred to be in spaces that used color regionally. All these results set forth clearly that the perception of colors and the usage rate of color in a space can change.

The data obtained from this study could hold a light on the design of high-quality spaces that could answer the physical and psychological needs in the living spaces of users. Care should be taken for the needs of the people who would use that space and the function of the space when determining the color that would be used and the color usage rate. At the conclusion of the study, concrete evidence was presented about perceptual attributes known for colors by designers and implementers and that it would be different when the color usage rates change. The results set forth that known positive or negative impressions of colors could be changed completely with the conscious changes that would be made on the usage rates.

This study has been prepared in a digital environment in order to address the effects of colors and usage rates in a living space. In future studies, spaces with different functions such as offices, hospitals, cafes can be used instead of living spaces. Similarly, by changing colors and usage rates, the effects of different colors and different usage rates on the perception of space can be studied. On the other hand, the colors whose effects were investigated in this study were used on the wall surface on the right side of the space. In future studies, the effects of colors on user preferences on other wall surfaces, floor and/or ceiling surfaces of the space can be examined. Furthermore, by forming experimental environments where real spaces are used, it could provide for the participants to experience the space with all their senses.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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