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Perceptual and emotional effects of light and color in a simulated retail space

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Abstract

This article aims to address two aspects of lighting often treated intuitively by designers in charge of creating retail atmospheres, that is, the impact of color and light distribution, as design variables. The study comprised a controlled experiment with a repeated measure design with three directions of lighting (front, overhead, and wallwasher), as the within-subject factor and four color combinations of the walls (yellow-blue, magenta, gray, and green-magenta), as the between-group variable. The perceptual (visually) and emotional responses of 184 participants revealed the interplay between light and color on these psychological outcomes. Specifically, the results showed that the overhead direction of lighting improves the appearance of the less favored color conditions, either in terms of lack of visual complexity (monochromatic) or color itself (gray). In turn, the wallwasher lighting emphasized these attributes, differing according to visual or emotional aspects. In retailing, emotional dimensions such as activation and evaluation are desired, and they were confirmed across all the lighting and color conditions of this study. The results provide designers with certain perceptual cues regarding colors and their lighting mode to create desirable impressions and affect in retail spaces.

KEYWORDS

color appearance, lighting, psychology, 1: 1 model

1 | INTRODUCTION

One of the contributions of psychology to the field of architectural design is the study of the perceived quality of the environment, which includes environmental appraisal subject to personal preferences, and environmental assessment concerned both with the objective evaluation of the measurable properties of environment and with people's judgments. Another psychological area which has assumed a central position in the domain of environmental evaluation studies is that of the affective component of evaluation, resulting in behavioral tendencies to approach or to avoid certain environments.[1] According to Küller,[2] an emotion is a process that evolves in stages, and proceeds in four steps corresponding to the neurophysiological events of arousal/activation, attention/orientation, reward/aversion (or evaluation), and coping/control. This so called *basic emotional process* is a response to changes in the human-environment relation.

Certainly, the environmental factors most studied in the field of Architectural Psychology are light and color,[3] which affect daily human experiences in a consistent manner, but in most studies to date researchers have looked either at room color or lighting in isolation. To understand how people perceive and are affected by spaces, these two aspects should be investigated at the same time.

1.1. | Antecedents

1.1.1 | Light and color in various spaces

The color of an interior space has effects at many different levels, including the perception of the room itself.[4] Research conducted on the effects of color and lightness on the perception of spaciousness showed the expected increase of perceived height with increases in ceiling and wall lightness, but the total brightness of the room was not the critical factor influencing the perceived height.[5]

As to color, empirical evidence indicates that emotional responses to color vary more strongly with regard to tone than to hue categories,[6] and the principle hues (ie, red, yellow, green, blue, purple) comprised the highest number of positive emotional responses, followed by the intermediate hues (ie, yellow-red, green-yellow, blue-green, purple-blue, and red-purple), and the achromatic colors (white, gray, and black).[7] Conversely, complementary colors, which are those diametrically opposite in the color wheel, provide a psychological balance of warmth and coolness.

A cross-cultural study carried out in real work environments at different seasons, determined that the workers' mood improved and reached its highest level when the lighting was experienced as just right but, when it became too bright or much too dark, the mood declined. The use of accents of color in the design might contribute to a more positive mood during the darkest season of the year.[8] The significant role of light in evoking atmospheres in comparison to other environmental features was demonstrated, from field studies carried out in urban exterior environments[9] to interior retail locations.[10]

Lighting can reinforce architectural planes, geometry and features.[11] Indeed, the direction of lighting has been generally used to describe how the perception of objects and space can vary by means of light,[12] and the *flow and sharpness* of light were proposed to prescribe lighting practice.[13]

Conversely, a sustainability approach argued that a reduction in the energy used in installations can be achieved by choosing an appropriate light spectrum or light distribution,[14] as well as illuminated walls.[15]

1.1.2 | Light and color in retail spaces

Lighting can be used to create excitement, and exciting store design has been identified as a contributor to purchases.[11] Nevertheless, this study does not intend to link the visual and affective evaluations with shopping behavior. The theoretical background was provided by previous research that demonstrated that the manipulation of lighting can affect perception and emotion and thereby create a pleasant ambience suitable for spending time, which is a desirable requisite for purchasing.

The concept of atmosphere referred to as *the quality of the surrounding space*, is central in retail spaces, and lighting and color seems to be central in evoking *atmospherics*, a term defined as *the effort to design buying environments to produce specific emotional effects in the buyer that enhance his purchase probability*.[16]

Atmosphere was also defined as the affective evaluation of the environment, and its perception is expected to be a more stable concept than mood,[17] even shoppers can be induced to behave in certain ways, based on the atmosphere created in retail.[18] The literature relating to color psychology in the context of marketing states that about 62%-90% of the assessment is based on colors alone, influencing moods and feelings, positively or negatively, and, therefore, influencing attitudes toward certain products.[19]

In retail environments, the decision to buy can have a greater emotional aspect than a functional one. An investigation on the effect of architectural lighting on social milieus and brand personalities for marketing strategies was conducted with eight light scenes in an experiment room, and found that brightness, color temperature, and chromaticity were predictors for several brand factors.[20] As for stage lighting, retail spaces require the enhancing of visibility, motivation, composition, and mood, achieved by the controllable properties of light: intensity, form, color, and movement.[21]

1.2 | Problem and hypotheses

This study aims to address the impact of color and its lighting mode, as design variables. A retail space constitutes a good testing ground for these aspects and might provide designers with certain perceptual cues regarding the use of light and color in such places where attracting attention is the target.

Colors can contrast in hue, value, and saturation. Although complementary colors are contrasting but not all contrasting colors are complementary, in this study, for the sake of comparison, the selected four color schemes were named as: monochromatic (magenta), achromatic (gray scale), contrasting (yellow-blue), and complementary (magenta-green). These wall color conditions were lit by three directions of lighting: front, overhead, and wallwasher, while keeping the illuminance level and the type of lamp fixed as well as its correlated color temperature.

The study comprises a repeated measure design with the direction of lighting as the within-subject factor and the color of the walls as the between-group variable.

The main hypotheses of this study can be summarized as the lighting distribution, provided by the directions of lighting, and the color of the walls (the architectural envelope) of a retail space, will affect perceived quality indicators and basic emotions.

Specifically the hypotheses state that:

i The impact of the different color schemes will be subject to their lighting mode.

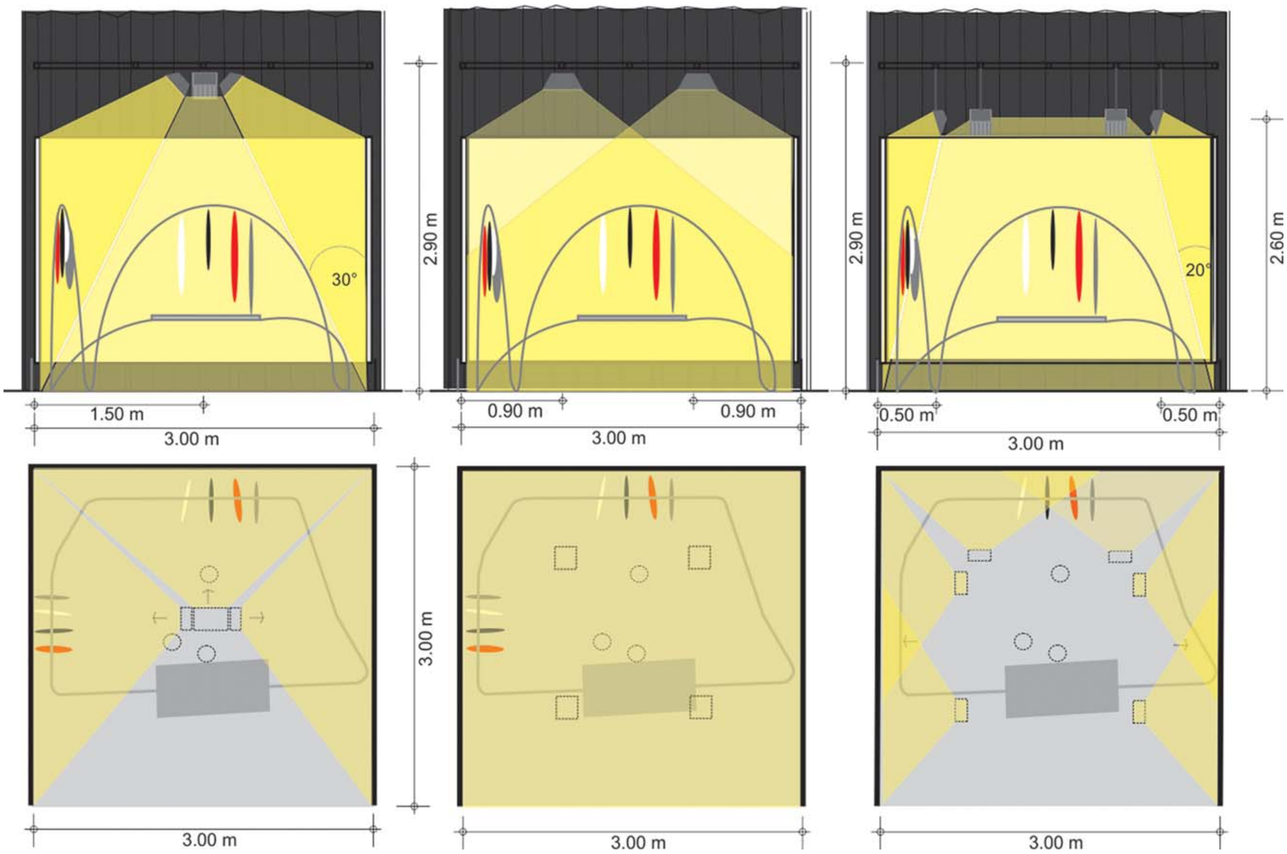

FIGURE 1 Layout and plan view of the luminaires arrangement and light distribution in frontal, overhead, and wallwasher lighting

ii Saturated colors like magenta will provoke activating emotional responses.

iii Perceptual and emotional assessments will show no difference between lighting/design experts and lay people.

2 | METHOD

2.1 | Setting (simulation setup), participants and procedure

The retail space was created inside a dark and temperature controlled laboratory room, which consisted of a 1:1 mock-up with three interchangeable wooden walls ($d = 3$ m, $w = 3$ m, $h = 2, 30$ m) painted with different color combinations: contrasting (yellow-blue), monochromatic (magenta), achromatic (gray), and complementary (green-magenta). Due to scale and proportion issues related to the total space, the illumination plane was set at 2.30 m. The colors of the walls and their combinations were selected based on theoretical considerations and conclusions drawn from the review of the background on the subject. For example, that monochromatic designs containing various shades and tints of one hue, are most effective for communicating simple messages, while multiple-color combinations can add depth, complexity, and additional meaning to design.[22,23] Also, complementary color schemes constitute the basis of harmonious design, even when they are placed next to each other, the effect is both stimulating and pleasing.[24]

With the passage of time, people change preferences for colors and color consultants predict and set color trends by taking into account the idiosyncrasies of various segments of the population. Although the prediction is more an art than a science, pallet pundits have a strong influence on marketing.[19] For this study, the magenta color was chosen for two reasons: as a non-spectral color (referenced by Pantone as "radiant orchild," 18-3224) and as a trendy color in retail spaces, set by a national Trend Observatory.[25] Due to previous trials, it was decided to experiment with the complementary color of magenta (green) according to CIELAB system. The color gray was selected as a non-color or colorless condition.

In spite of the low energy efficiency, halogen lamps were chosen because at the time of this study, they were the most used type of lamp in retail environments because their accurate color rendering. Thus, the ceiling was delimited by a lighting support system consisting of a mounting grid with halogen lamps (300/500 W, 3000 K), in three directions: front (1500 W/21 000 lm), overhead (1200 W/17 000 lm), and wallwasher (1800 W/24 000 lm), as well as accent lighting from halogen reflector lamps for the clothes exposed (Figure 1).

FIGURE 2 Photo of the 12 experimental conditions (3 lighting × 4 colors).

To equalize the levels of illuminance for the three lighting scenes, different wattages were required.

The floor was covered by a gray rough carpet. See Tables 2 and 3 for the color references and photometric measurements.

As participants were not allowed to walk through the examination space and to create a more attractive space, a tubular silver frame which rises and falls in a loop was put inside the setting and behind the show-table. This curving structure was displayed along the front and left walls working as a rack. See Figure 2.

Laboratory simulations like this still have advantages over other techniques such as the nowadays commonly used image video projections. A study[26] for retail environments explored to what extent image techniques could represent the reality for applied research related to lighting and brand communication, and found that, in spite of simulations could reduce cost and time compared to mock-ups in real size, lighting characteristics such as correlated color temperature and chromaticity significantly differ when image evaluations are based on a media monitor or video projection and are compared to the real laboratory.

Table 1 describes the participants ($N = 184$), divided into three groups of lighting and architecture experts, lighting and architecture students, and lay people, all screened as normal color vision subjects.

For each color condition carried out on different occasions, the participants were instructed orally in an adjoining room about the aim of the experiment (*to investigate the effects of light and color on different perceptual responses*), as well as about the reading and comprehension of the semantic scales (for example: bright-dim, simple-complex, wide-narrow) selected for the assessment. According to Flynn's methodology procedure for measuring subjective impressions in response to lighting stimuli,[27] the participants then entered into the experimental setting where the three lighting arrangements were shown in 15 seconds. Two of the participants took a seat in front of the examination space and filled in the form, while the rest waited for their turn. The participants had as much time as they needed to fill in the

TABLE 1 Description of the three groups of participants throughout the different color conditions and under the three lighting directions

N Gender	Age	N Background	N Color Condition	N Lighting Condition
Female: 100	Mean: 26	Experts: 25	Contrasting: 30	Front: 184
Male: 84	SD: 6.7	Students: 123	Monochromatic: 52	Overhead: 184
	Range: 18-60	Naive: 36	Achromatic: 54	Wallwasher: 184
			Complementary: 48	

questionnaire so the lighting condition was changed once they finished. The procedure involved approximately 15 minutes including 60 seconds' adaptation before each lighting direction, which were provided randomly for each color condition. All sessions were performed between 14:00 and 16:00 hours, to equalize the circadian status of the subjects.

In this study, light/lighting is referred only to light/lighting distribution as that is what was manipulated.

2.2 | Measures

2.2.1 | Objective measures: color and light components

The colors of the various constituent elements of the space were characterized by means of the CIELAB system using a spectroradiometer PhotoResearch PR 715, Illuminant D65/A, Observer at 10°.

The lighting distribution in terms of vertical illuminance and luminance was measured at 9 points in a grid. Table 3 shows the almost constant illuminance levels across the different experimental conditions while luminance levels differ according to the color of the walls.

The differences in lux between the right and the left walls are due to the accent lights included in the measurements. As expected, the illuminance mean value over the table was higher for the overhead solution: 1390 lx, being 594 lx for the front, and 537 lx for the wallwasher.

Photometric measurements were carried out by means of a luxmeter TES model 1339 and a luminancemeter Minolta model CS.100A.

2.2.2 | Subjective measures: perceptual and emotional assessments

Perceptual and emotional assessments were included in a questionnaire composed of two sections. The first section contained seven- graded 30 pairs of opposite semantic scales referred to visual/perceptual and affective aspects, inspired mostly by Flynn's protocol,[27] and others specially selected and tested for this study. They were answered in terms of "*Do you think this space is*. . .. ".

The affective dimension was reinforced in the second section of the questionnaire by means of a specific emotional test[4] related to the basic emotional process of activation (tiredness, alertness, drowsiness), orientation (interest, efficiency, indifference), evaluation (safety, friendliness, sadness), and control (hesitation, independence, strength). Each of these 12 four-grade rating scales was answered in terms of "*Please rate the feeling caused by this space*".

Exploratory and confirmatory factor analyses, as well as perceptual and emotional indices, were computed for each section of the questionnaire (some items were reversed for the analysis). In this way, the higher the score, the more positive the judgment. Both indices showed an acceptable internal reliability (Cronbach's alpha = 0.66 and 0.72, respectively).

To test the hypotheses, one-way and multivariate analysis of variance with repeated measures were calculated, with lighting direction as the within-group variable and wall color

TABLE 2 Color references of the space according to CIELAB system in terms of Lightness, Hue, and Chroma

Elements	*L*	*a*	*b*	*H*	*C*
Walls:					
Magenta	58.54	32.12	−12.56	5.91	34.49
Dark Gray	40.12	−0.86	−2.17	4.33	2.33
Light Gray	50.23	−0.32	−3.24	4.61	3.25
Yellow	70.56	27.26	49.98	1.07	56.93
Blue	42.29	−14.68	−25.54	4.19	29.45
Green	53.6	−41.53	6.26	2.99	42.00
Floor:	38.91	−0.92	−2.19	4.31	2.37
Table:	57.96	−1.09	−4.25	4.46	4.39
Clothes:					
White	88.76	1.54	−3.85	5.12	3.89
Red	45.37	56.82	20.9	0.35	60.55
Gray	30.54	2.72	−5.88	5.14	6.48
Black	20.22	1.8	−1.76	5.51	2.52

TABLE 3 Mean values of vertical illuminance (*E*, lux) and luminance (*L*, cd/m^2) of walls (including accent light on clothes), at each color and lighting condition

			Front		Overhead		Wall Washer	
	Color	Wall	*L* (Cd/m^2)	*E* (Lux)	*L* (Cd/m^2)	*E* (Lux)	*L* (Cd/m^2)	*E* Lux
Monochromatic		FRONT	36.40	347.00	21.85	419.85	37.74	563.00
	Magenta	RIGHT	37.35	257,78	26.95	201.22	36.94	400.89
		LEFT	33.69	434.38	23.60	299.61	33.95	351.85
		Mean	36	346	24	307	36	439
Achromatic	Dark gray	FRONT	19.53	423.61	11.58	412.15	24.17	526.61
		RIGHT	21.54	304.16	15.71	210.66	31.79	396.44
	Light gray	LEFT	20.36	490.46	10.47	333.00	25.06	345.69
		Mean	20	406	13	319	27	423
Contrasting	Yellow	FRONT	57.70	526.30	33.51	431.30	62.37	537.92
		RIGHT	15.05	282.44	9.05	189.55	20.70	423.00
	Blue	LEFT	23.61	446.30	18.33	335.07	25.52	384.53
		Mean	32	418	26	319	36	448
Complementary	Green	FRONT	27.61	503.15	17.70	410.77	29.54	515.77
		RIGHT	33.50	279.33	21.15	182.33	42.61	376.66
	Magenta	LEFT	32.35	463.00	28.12	363.54	39.48	366.46
		Mean	31	415	22	319	37	420

as the between group variable being used. The level of significance was set to $P = .05$ (SPSS 15.0).

3 | RESULTS

3.1 | Indices

Two indices were computed. One was based on the 30 perceptual scales (*perceptual index*) and the other on the 12 emotional scales of the standardized test (*emotional index*).

Figure 3 shows that in the achromatic (gray) and monochromatic (magenta) conditions of color, the perceptual assessments improve from the front lighting up to the overhead and then fall again for the wallwasher direction. Conversely, the contrasting (yellow-blue) and complementary (green-magenta) color combinations reach their highest evaluation under the wallwasher lighting. The same pattern is observed for the emotional assessment, but the perceptual ratings were slightly higher in the contrasting color scheme, and the emotional ones in the complementary. Mean value and standard deviation for the items included in the indices are shown in Tables 4 and 5.

Also, a low but significant correlation of 0.152 (Pearson 2-tailed) was found between the mean luminance of walls and the perceptual index in the front lighting. When the luminance value of the desktop was computed into this mean, a significant correlation emerged in the overhead direction of lighting (–0.174), as well as the emotional evaluation in the wallwasher direction of lighting (0.156).

To probe further into these relationships, analyses of variance with repeated measures were performed for each index. The result showed a significant main effect of the direction of lighting on both indices: perceptual (F (2.179) = 3.075, $P = .04$) and emotional (F(2.179) = 4.43, $P = .01$). The same analyses of variance were used to contrast the assessments of experts and lay people, and no significant effects were found (within or inter subject).

3.2 | Factor analyses

3.2.1 | Exploratory factor analysis

The factor analysis of perceptual/visual variables revealed the clearest factorial structure under the wallwasher direction of lighting, which resulted in six orthogonal factors

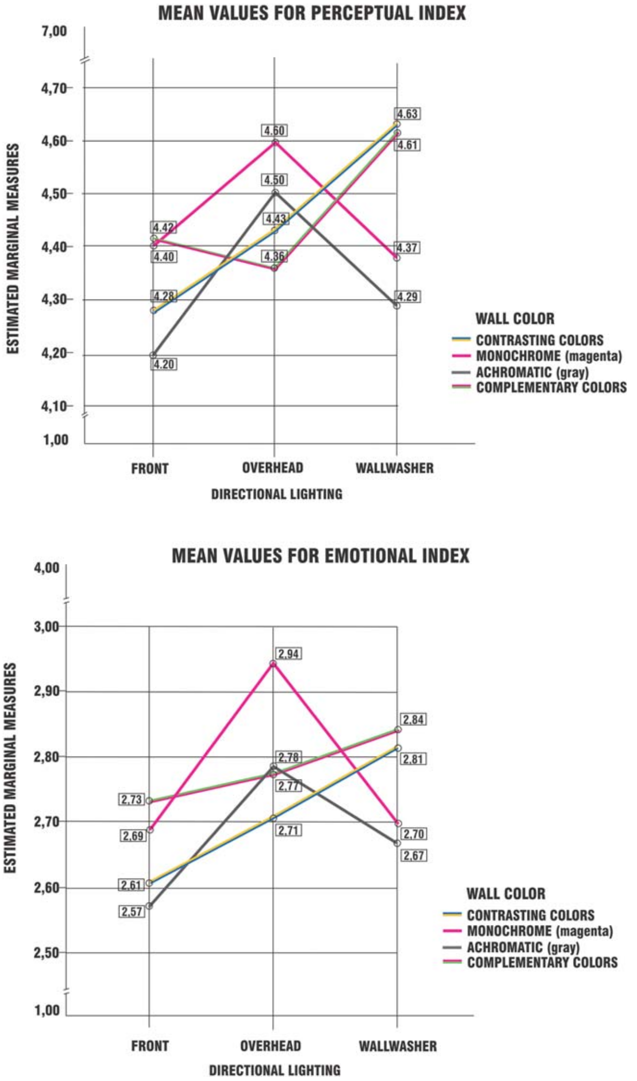

FIGURE 3 Means of perceptual and emotional indices at each direction of lighting and color condition.

accounting for almost 60% of the total variance (Table 6). The first factor (29%) showed the evaluative dimension, the second factor (10%), loaded in perceptual effects directly related to light and color characteristics, the third factor (8%) clearly represented spaciousness, the fourth factor (5%) referred to spatial complexity, the fifth factor (4%) loaded in two scales related to color tone and distribution of lighting, and the sixth factor (4%) was loaded in the single scale of virtual-real. The last three factors exhibit lower contributions to the variance as well as poor Cronbach's alpha. The single-item of factor six was not appropriate for a reliability analysis.

3.2.2 | Confirmatory factor analysis

The psychological test used in this study analyzed emotions in terms of four basic emotional qualities: activation, orientation, evaluation, and control.

The results showed that *activation* and *evaluation* were similar to those obtained by Küller, but scales belonging to *orientation* and *control* were distributed in different weighing factors. Nevertheless, the revealed eight factors explained 65% of the variance. The Cronbach alphas considered to indicate internal consistency (reliability) of every factor were suitable (see Table 7). To test how well the data fit the expected factor structure, the Measure of Sampling Adequacy (KMO) was used and showed a value of 0.763, which would be labelled as "middling."

Furthermore, an analysis of each individual scale of the emotional dimensions, indicated the existence of a significant effect of the wall color and the direction of lighting as follows: the complementary color scheme and the front lighting on the state of alertness ($P = .01$), the monochromatic magenta and overhead lighting on interest ($P = .04$), and as a slight effect of the contrasting color scheme and front lighting on no- indifference ($P = .06$). (See Table 8).

4 | DISCUSSION

By means of the simulation in laboratory of a retail environment, this study aimed to address two aspects of lighting design often treated intuitively in an effort to create atmospheres. One was to contribute with empirical evidence on the relationships between color and emotions in such spaces, and conversely to stand out light distribution, a missing variable in lighting research. In this regard, the directions of lighting selected to characterize the effect of light as well as the selection of colors, worked well in relation to these aims.

The study was carried out using a 1: 1 mock-up with different combinations of color on its walls, namely: contrasting (yellow-blue), monochromatic (magenta), achromatic (gray scale), and complementary (magenta-green), all under three directions of lighting: front, overhead and wallwasher.

The hypotheses of this study were made up from previous research on the impact of light and color from different environments on human perception and emotion, and specifically in retail environments. Thus it was hypothesized that the lighting distribution and the color of the architectural envelope or walls of a retail space will affect perceived quality indicators and basic emotions. The sample consisted of 184 persons whose responses did not differ between experts and lay observers.

The results for both the perceptual and the emotional indices showed that the highest rates were obtained in the achromatic-gray and monochromatic-magenta color conditions under the overhead direction of lighting. For the other color schemes, the highest level of appraisal was informed in the contrasting yellow-blue and complementary green-magenta under the wallwasher lighting. In this lighting mode, it is important to note that the yellow-blue

TABLE 4 Mean value (*M*) and standard deviation (SD) for items included in the perceptual index, on the three directions of lighting (1 front, 2 overhead, 3 wall washer) and the four color combinations (scale 1-7)

Wall color		Perceptual 1	Perceptual 2	Perceptual 3
Contrasting	M	4.28	4.43	4.63
	SD	0.52	0.48	0.62
Monochromatic	M	4.40	4.59	4.37
	SD	0.75	0.62	0.85
Achromatic	M	4.19	4.50	4.28
	SD	0.83	0.60	0.77
Complementary	M	4.41	4.35	4.61
	SD	0.77	0.84	0.78

combination was more relevant for the perceptual/visual aspect and the magenta-green combination for the emotional one. An explanation for this finding might be that the overhead lighting improved the appearance of the less favored color conditions, either in terms of lack of visual complexity (monochromatic) or color itself (gray). In turn, the wall-washer lighting emphasized these attributes. This result is fully in line with previous research about the deep influence of color and complexity of the visual field on people.[4]

In this study, the wallwasher lighting was the powerful direction in revealing the perceptual dimensions, in which evaluation, light/color, spaciousness and spatial complexity accounted for half of the total variance of the data. The reliability exhibited by these factors demonstrates that participants used the rating scales in a consistent way across the different experimental conditions. As to the emotional dimensions, the confirmatory factorial analysis showed that 65% of the variance of the data was explained. Among the four dimensions obtained by Küller, *activation* and *evaluation* were confirmed, and they are closely related to affective states identified in previous research of retail atmosphere in terms of excitement and pleasure.[11,16,18,20] The remaining dimensions of *orientation* and *control* resulted not relevant for this kind of space.

From the analysis of the emotional scales one by one, emerged that the scales related to alertness and interest were reported in the complementary and monochromatic conditions, under the front and overhead direction of lighting, respectively. As it was hypothesized in this study, these psychological states might be elicited by the magenta color, which was present in the two color schemes.

The perceptual index correlated significantly with the spatial luminance, and ample evidence exists about the importance of wall luminance for accentuating architectural elements as well as enhancing some aspects of visual perception and boosting nonvisual parameters.[14,28,29] In this sense, the lighting modes directed to the vertical surfaces such as the front and wallwasher did, were particularly suitable to

TABLE 5 Mean value (*M*) and standard deviation (SD) for items included in the emotional index, on the three directions of lighting (1 front, 2 overhead, 3 wall washer) and the four color combinations (scale 1-4)

Wall color		Emotional 1	Emotional 2	Emotional 3
Contrasting	M	2.60	2.70	2.81
	SD	0.35	0.50	0.37
Monochromatic	M	2.68	2.94	2.69
	SD	0.58	0.45	0.68
Achromatic	M	2.57	2.78	2.66
	SD	0.58	0.47	0.46
Complementary	M	2.73	2.77	2.84
	SD	0.55	0.61	0.56

TABLE 6 Factor analysis (varimax rotation) for the perceptual scales based on the four color conditions under the wall-washer lighting ($N = 184$)

Scales	Factor 1 (α = .89)	Factor 2 (α = .69)	Factor 3 (α = .75)	Factor 4 (α = .55)	Factor 5 (α = .10)	Factor 6 -
Beautiful-ugly	0.65					
Focused-unfocused		−0.62				
Big-small			0.75			
Visually warm-cool					0.55	
Dislike-like	−0.75					
Short-long			−0.71			
Simple-complex				0.69		
Pleasant-unpleasant	0.67					
Glare-non glare		0.60				
Public-private						
Confined-spacious			−0.75			
Relaxing-tense	0.67					
Bright-dim		0.72				
Stimulating-depressing		0.69				
Distinct-vague		0.68				
Satisfying-frustrating	0.64					
Colorful-colorless		0.74				
Functional-non functional						
Vivid-faded		0.76				
Ordinary-special	−0.57					
Messy-neat	−0.51					
Stable-unstable				0.51		
Minimalist-motley				0.78		
Virtual-real						0.88
Meaningful-not meaningful	0.66					
Vulgar-fine	−0.80					
Nice-not nice	0.60					
With message-indifferent	0.68					
Wide-narrow			0.59			
Uniform-non uniform					−0.70	
Total variance %	29	10	8	5	4	4

Only factor loadings larger than 0.50 are shown.

TABLE 7 Factor analysis (varimax rotation) for the emotional scales based on all the color and lighting conditions ($N = 184$)

	Factor 1 (α = .69)	Factor 2 (α = .74)	Factor3 (α = .35)	Factor 4 (α = .49)	Factor 5 (α = .64)	Factor 6 (α = .42)	Factor 7 (α = .55)	Factor 8 (α = .48)
Activation:								
Tiredness	0.78							
Alertness						0.76		
Drowsiness	0.76							
Orientation:								
Interest		0.76						
Efficiency				0.70				
Indifference								0.68
Evaluation:								
Safety		0.60						
Friendliness		0.84						
Sadness	0.73							
Control:								
Hesitation							0.73	
Independence					0.70			
Strength			0.76					
Total variance %	17	15	11	10	4	3	3	3

Only factor loadings larger than 0.60 are shown.

enhance the colorfulness of the surrounding. It is important to note that among the selected colors, the yellow color has the highest values in term of lightness and chroma. In line, other studies have proved that observers preferred the spectral power distributions under which the chroma and colorfulness values of the object colors were higher.[30]

Recommended illuminance for interior retail environments ranges from 75 to 750 lx for vertical target.[11] In this study, the illuminance levels of vertical surfaces were kept constant across the different experimental conditions while luminance levels differed according to the color of the walls. In all color schemes, the lowest luminance mean is expressed in the overhead lighting while the highest is reached in the wallwasher direction. In comparison, the overhead direction of lighting consumed less energy (1200 W), and produced the highest horizontal illuminance level at the tabletop (1390 lx), and also provided more illumination over the floor.

Only in the U.S. electric lighting accounts for about 42% of the electricity used in retailing.[11]

TABLE 8 The relationship between the color of the walls on one hand and the emotional scales on the other at the three different lighting conditions (One-way analyses of variance, $N = 184$)

Wall color	Emotional scales	Lighting direction	*M*	SD	*F*=	*P*=
Contrasting	Indifferent (-)	Front	2.63	0.80	2.49	0.06
Monochromatic	Interest	Overhead	3.08	0.88	2.70	0.04
Gray scale	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Complementary	Alertness	Front	2.65	1.02	3. 76	0.01

In places with a high availability of daylight, the sustainable use of daylight as a lighting system is not always possible, mainly due to its thermal and noise contribution.[31] In situations like this, the design decision related to color and lighting becomes very important. A possible contribution to this field might be taken from the Helmholtz-Kohlrausch and Hunt color appearance effects.[11,32] The first states that the perceptions of brightness and lightness depend on both luminance and chromaticity, therefore it is possible to increase the perception of brightness at constant luminance by choosing a light source or surface finishes that are more chromatic. In addition, the Hunt effect provides that the colorfulness of chromatic objects increases with luminance, therefore, to create the perception of a colorful environment, highly saturated surface colors will be required for low light level environment, and conversely, less saturated surfaces can be used for high light level environments.[11] Reinforcing this idea, bright wall colors create higher luminance in the vertical plane and enhance the impression of brightness, and higher degrees of reflection also brighten other surfaces in the room.[15] As to metrics, Cuttle proposed the concept of mean room surface exitance as a basis for lighting standards, by means of the provision of acceptably bright surroundings, and for this, lighting standards will be based on reflected light arriving at the eye.[33]

In conclusion, the results presented in this study show that certain visual and emotional effects might be achieved by selecting the proper color of the space and its lighting mode. Consequently, in the design of a space, the choice of colors should not be made without taking into account the distribution of light in that space; in turn, a lighting design should not be planned without considering the color of the surrounding and objects into the space.

This study might show two limitations. One was not to keep constant the luminance in all the color conditions, but rigorous measures and characterizations of them provided the basis to establish the relations shown in this article. The second limitation might be ascribed to the apparently random selection of specific colors used, which may lead to the conclusion that findings cannot be generalized to other colors. It would be impossible to test with all the colors and their combinations; hence the decision was made based on previous studies as well as on referenced trend observatories, which lent enough support to test the hypotheses.

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