International Journal of Architecture and Urban Development
Vol. 13, No.1, P 15-24 . Winter 2023

E-ISSN 2345-2331
Applied Research Article
DOI: 10.30495/IJAUD.2022.62361.1550

Defining the Color Weight of Residential Building Façade, Using Q-Factor Analysis

[1]*Maryam Mehdipour*, [2]*Seyed Abbas Yazdanfar* , [3*]*Ahmad Ekhlasi*, [4]*Bahram Saleh Sedghpour*

[1]*Ph.D. Graduated, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran.*

[2]*Associate Professor, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran.*

[3*]*Associate Professor, School of Architecture and Environmental Design, Iran University of Science and Technology, Tehran, Iran.*

[4]*Associate Professor, Department of Educational Psychology, Faculty of Humanities, Shahid Rajaee Teacher Training University, Tehran, Iran.*

Recieved 05.08.2021; Accepted 03.01.2022

ABSTRACT: Designing the facade's color based on user evaluation is necessary due to the effect of color on people's evaluation. To evaluate the facade's color, its combination should be categorized. The emotional dimensions of color evaluation should be assessed due to the variety of emotional scales of color evaluation. Thus, the question arises: What are the emotional scales describing the facade's color and components. During a study, temperature, harmony, and weight were considered to describe the color in facades. This study used a combination of qualitative and quantitative methods to examine the components related to defining the color composition's weight scale. First, some components were identified to determine the weight of the color combination through a semi-structured interview. Based on the results, a questionnaire was prepared. The final results were obtained using the Q method analysis with the help of color strips and HSL codes. Therefore, to describe the combination color of the facade as light and heavy, the facade with a light color combination has at least 30% openings. At least 70% of facade areas and openings have a hue with more than 90% lightness. In addition, the saturation of at least 70% of the area is less than 30% and 5% with warm and cool hues, respectively. At least 70% of facade areas and openings have a hue with less than 65% lightness and a heavy color combination.

Keywords: *Facade, Visual evaluation, Color scales, the weight of color combination, Q-method analysis.*

INTRODUCTION

Color patterns in urban spaces play a significant role in understanding the visual qualities of the city. The color facades as part of the urban space significantly affect the experience and evaluation of the environment. The issue of facade color in the aesthetic controls of urban planning policies in different countries demonstrates its importance. The color combinations in artificial environments affect behaviors, feelings, experiences, and people's judgments about the quality of the environment and highlight the need to reconsider traditional approaches of color design in the environment, including the approach of considering color as a secondary element in constructing and selecting the color based on the personal preferences of the designer which fail to meet the aesthetic expectations and general preference (McLachlan, 2013). However, designing the facade's color following the users' needs and scientific studies can adjust environmental conditions. The factors mentioned above make it necessary to examine the facade's color based on environmental perception, user evaluation, and knowledge of color evaluation.

Using abstract color samples instead of Contextual color, focusing on monochromes, and not paying attention to color combination, as well as considering a universal and definitive response to color evaluation are among the challenges in most color evaluation studies, in which the color preference of one object does not resemble in another one (Sarica & Cubukcu, 2018). Based on the results, underlying factors and individual characteristics affect the perception and evaluation of the facade's color (Fridell Anter, 2000). Thus, the color combination of the facade and the evaluation of users should be assessed.

Few studies have been conducted on evaluating the color of the interiors (Jalil et al., 2012; Savavibool et al., 2018) and even less on the facades (Janssens, 2001; Garcia et al., 2003; O'Connor,

*Corresponding Author Email: *ekhlassi@iust.ac.ir*

2008; Cubukcu & Kahraman, 2008; Sarica & Cubukcu, 2018), most of which have focused on monochrome evaluation such as O'Connor (2008), which studied the emotional and cognitive evaluations of monochromes on single-story buildings in terms of harmony with their surroundings' color. Only a few studies have explored color emotions for color combination of facades, such as Sarica & Cubukcu (2018), which compared people's responses to abstract color combination and those in the facade of urban complexes.

During evaluating environmental color, color is described either based on its physical dimensions such as hue, lightness, and saturation (Plataniotis & Venetsanopoulos, 2000; Janssens, 2001; O'Connor, 2008; Cho, 2015; Han et al., 2016; Santosa & Fauziah, 2017; Shinomori et al., 2020) or based on emotional scales such as harmony-contrast, warmness-coolness, lightness-heaviness, and the like (Fang et al., 2015; Koo & Kwak, 2015; Al-ayesh et al., 2016; Chamaret, 2016; Hanafy & Sanad, 2016; Kuang & Zhang, 2017; Manav, 2017; Huang, 2018; Gunes & Olgunturk, 2019; Boeri, 2019 & 2020; Liu et al., 2020); including O'Connor (2008), which utilized scales of harmony and contrast based on Sydney urban planning policies, or Sarica & Cubukcu (2018), which studied the color combination of urban complexes based on the scales of cool/warm and harmonious/contrasting. There is no standard instrument for selecting evaluation scale and describing the color combination of facade due to the different scales in different studies. Therefore, the evaluation scales should be determined, and the color combination of the facade should be described.

Accordingly, this study aims to investigate the emotional scales of the color combination of the facade and determine the quantitative components of detecting the weight scale (this scale is one of three bipolar emotional scales resulting from the second step of this research). The other two scales were presented in the previous two studies of the authors[1]) to define and classify the color combination of the facade.

MATERIALS AND METHODS

Methodology

The present study is considered exploratory in terms of aim and the combination of qualitative and quantitative methods in terms of method. The purposeful and small-scale selection of participants approaches it to the qualitative method, and data analysis through factor analysis makes findings quantitative method completely (Sepasgar Shahri & Manouchehri, 2014).

As shown in Figure1, first, written comments on the emotional scales of color combination evaluation were studied using content analysis from various sources and documents from 1960-2020. A total of 40 papers evaluating the colors using emotional scales were selected from among them. After examining the full-text versions of the chosen sources, 97 color-emotion scales of color evaluation were collected. Based on the studies, only ten scales, cool-warm, contrasting-harmonious, hard-soft, heavy-light, and passive-active, could be defined on the color physical dimensions among 97 scales. There was no theoretical agreement on other scales due to individual and contextual differences.

Next, as the first Delphi survey tool, a questionnaire was

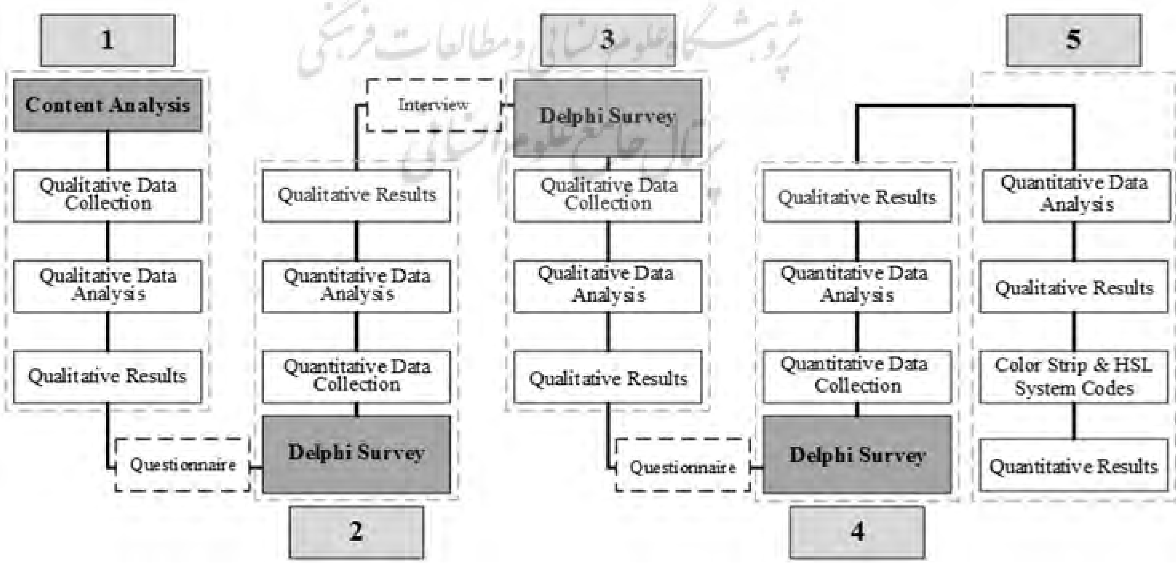

Fig. 1: The research process

developed based on 100 photograph images of the facade and five color-emotion bipolar scales. Twenty experts evaluated it (e.g., experts in graphics, architecture, industrial design & painting) in design and color. Since in the Delphi survey, the sample size of experts cannot be significant, the Q-method[2] was used to analyze the questionnaire data. According to experts, the result of this step of the survey and Q-method analysis presented that the color combination of facade could be classified in three scales of cool-warm, heavy-light and contrasting-harmonious. Also, based on this analysis, out of 100 images, the images that were the most suitable representative for each of these three scales were selected by experts.

The authors have examined the two scales of temperature and harmony in other studies, and in this study, only the weight scale (light-heavy) has been examined. Accordingly, in the following procedure, the nine components describing the weight of the color combination of the facade were extracted based on the selected images of the previous stage and through semi-structured interviews with five professors in urban planning and architecture, shown in Table 1. The interviewees define these components. It is worth noting that nine components of this step, along with ten selected weight scale images, provided the survey instrument in the final stage, which was completed by the first 20 experts in the field of design and color. Q method was used to analyze the data in two stages. Then, the final selected photos' color combination was examined by HSL system codes and the color strip. Thus, the components affecting the assessment of the weight of the color composition in the facades were extracted. The components affecting the assessment of the weight of the color composition in the facades were extracted from its results using the color strip and HSL codes of the final selected images.

Since in the HSL system, color properties have numerical values, i.e., hue (H), luminance (L), and saturation (S), this system has been used in research. Figure 2 demonstrates this system. In this system, the hue is measured at an angle around the vertical axis and has a range of values between zero to 360 degrees and starts from red in zero degrees. This value shows the spectral combination of color. Luminance varies between 0 and 1, with zero to 100 in Photoshop. The value of luminance is relative. Saturation is a ratio that extends from zero (for example, on-axis I) outward to a maximum of 1 at the cone level radially, shown in Photoshop with values from zero to 100. This value demonstrates how far a color is from a gray color with the same luminance (Sarica & Cubukcu, 2018).

Survey of the Photos of the Facade

Contextual colors should be utilized to study color evaluation and preference in architecture and urban design (Cubukcu & Kahraman, 2008). Full-scale models are not always affordable, efficient, and available. Many studies use photographic images instead of real spaces and objects (Janssens, 2001). These studies have shown that the response to color photographs is the same response to the real setting. So images of the facade were used in the present study. To study the color emotional scales describing the color combination of the facade, it was necessary to capture photos that could be an appropriate representative of the residential facade in Tehran. Due to the lack of similar research in Iran and standard tools to record the photos. The 12 criteria considered in the studies of 'Cultural, Social and identity typology of Tehran neighborhoods' by the Institute of Social Studies and Research (2015) were used to select the desired neighborhood. Five architects and urban planners selected 11 neighborhoods in Tehran to capture photos. Then, photos were recorded from the facades of these 11 neighborhoods. Five former experts chose the Koy-E-Nasr

Table 1: The nine components defining the weight of the color combination of the facade from the interviews

No	Components describing the weight scale
1	Lightness level of color combination
2	The saturation level of color combination
3	Number of hues in combination
4	The surface area of hues in combination
5	The surface area of openings
6	Lightness level of the color of openings (windows) in the image
7	The formal composition of façade
8	(The form of openings (windows
9	The building’s exterior details

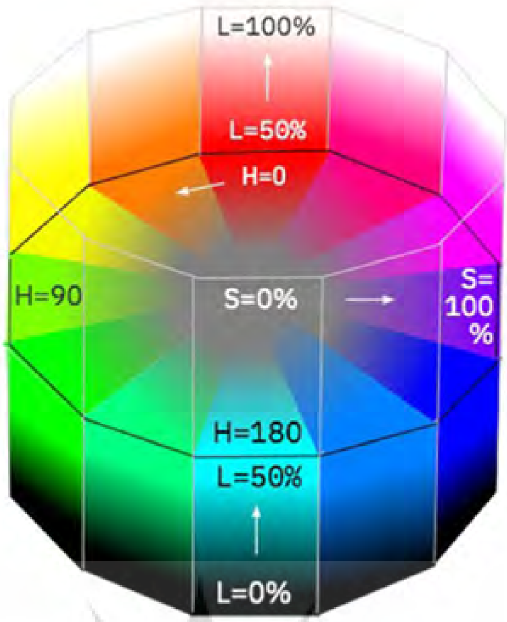

Fig. 2: The HSL colo system (Source: Jewett, 2020)

neighborhood to record the final photos for the following reasons:

- The chess streets that were almost equal in width (Ability to record images from the same distances)
- Buildings of almost the same age;
- Buildings with almost the same width and number of floors;
- Buildings with the same function (almost all residential).

Accordingly, the facades of residential buildings in the Koy-E-Nasr neighborhood were photographed. The selection and survey of images of the facade were performed as follows:

Selection of the buildings: Since the age, function, and scale of the building are influential in evaluating its color (Janssens, 2001), photography of 6-7 story residential apartments, located in the northern plot of land with a width of approximately 9-12 meters, was done by a digital camera[3] at a straight and constant angle, 10 meters from the facade. The age of buildings was up to 10 years. Among 692 recorded images, 100 images were selected by five architects and urban planners for the next step of research. The criterion for selecting images was the lack of appendage and the complete view of the facade in the image.

Time and conditions of recording the images: The color of the facade changes based on the change of light at different times of the day as well as in different seasons and climates (Zareh & Lotfi, 2017), the photographs were recorded between 12:00 and 2:00 PM during one month (The time with minimal shadows).

Setting the white balance of the photograph images: The human brain corrected white discoloration in different lighting conditions. This correction is done using the 'preset manual' mode in digital cameras and photos captured with a white reference card[4] in constant light conditions. Levels setting in the Photoshop software are used to re-align (Tadayon et al., 2018).

The correction of photograph images: To have photograph images in the same viewing angle independent of perspective, the skew setting of the Transform tool in the Edit menu of Photoshop CC 2017 was used. The environmental colors in recorded photos of facades significantly affect its color evaluation (Cubukcu & Kahraman, 2008). Therefore, the adjacent facades were deleted and painted in neutral gray[5] while unique blue was chosen as the color of the sky[6] in each recorded image. The color of the ground floor in all images was considered darker, and visual appendages such as utility poles, power cables, and trees were deleted from the images as much as possible. Figure 3 shows the sample image of the residential facade.

Participants and Data Collection

During the content analysis of the documents, the population included all available studies and research in color evaluation and facade. To this aim, 100 images were chosen from all of the images were taken of the facades in residential buildings by five architects. Then, due to the exploratory and descriptive purpose of the research, 20 experts in design and art, including teachers of painting, architecture, industrial design, and graphics, were selected as the participants in both questionnaires based on their familiarity with the research topic, nonprobability, and targeted sampling with the small sample size. The sample in the semi-structured Delphi interviews included five architects and urban planners who were selected by snowball sampling, and the sample size was obtained based on theoretical saturation.

Reliability and Validity

To measure the reliability of the questionnaires, the internal consistency method and the calculation of Cronbach's alpha coefficient were used. The value of Cronbach's alpha coefficient in all of the first survey questionnaires was more than 0.7, and in the second survey, the questionnaire was 0.736, indicating the scales' acceptable reliability. To check the variables' appropriateness in the correlation matrix, the K-M-O test was used as a sample adequacy index; a value of more than 0.7 indicates the appropriateness of the data's correlations for factor analysis (Takane & Ferguson, 2011). This value is more than 0.7 in the first questionnaires, and as shown in Table 1, it is 0.706 in the second questionnaire, indicating that the sample size is sufficient. Significance less than 0.05 in Bartlett's test and Chi-square demonstrates that the correlation matrix is unique, and its value in Table 2 (0.00) has met this expectation.

RESULTS AND DISCUSSION

After the data analysis in SPSS software, it was found that there are seven factors with more than one total rotation sum of squared loadings based on 20 experts' views. The cumulative rate of 66.801% of the total factors means that about 66% of participants' thought is considered common, and less than 34% is regarded as an individual, which may be due to individual tendencies and awareness. This percentage indicates an external fact that has attracted 66.801% of the respondents' attention.

Table 3 indicates the data rotation matrix and the factor loadings statistics. The variables of each factor can be identified to use the statistics of this matrix. The variables with factor loadings of more than ±0.3 are considered as significant and placed in that factor category. As indicated in the rotated component matrix in Table 3, the first, second, and third factors include five, four, and three experts, respectively, and the fourth, fifth, sixth, and seventh ones each include two experts.

To find a common line of experts' thoughts about the components affecting the weight assessment of the color combination of the facade, the questions in which at least half of the experts of that factor gave them a score of 8, 9, and 0, 1 in each factor were considered. Then, Q-method analysis was conducted on the resulting factors for the second time, and all of the steps mentioned earlier were repeated to summarize the wide results obtained. The second stage of Q-method analysis resulted in several selected images regarded as the best example for light or heavy color combinations and determining the components affecting the weight of color combinations. Based on the results of the nine components obtained from the interviews

Fig. 3: Sample image of the residential facade

Table 2: K-M-O and Bartlett's test

K-M-O Measure of Sampling Adequacy		0.706
Bartlett's Test of Sphericity	**Approx. Chi-Square**	975.430
	Df	190
	Sig.	.000

Table 3: Rotated component matrix

	Component						
	1	2	3	4	5	6	7
VAR00019	.745	.051	-.039	-.147	.094	.212	-.072
VAR00006	.719	.341	.202	.165	-.114	-.039	.128
VAR00005	.623	.093	.072	.227	.177	.133	-.068
VAR00020	.583	-.178	.051	.032	.067	-.115	.064
VAR00009	.561	.145	.146	-.004	-.134	.280	-.003
VAR00001	.024	.858	.049	-.060	-.040	.042	.044
VAR00003	.209	.644	.122	.179	.392	.015	.006
VAR00015	-.01	.613	.135	.242	.420	-.248	.026
VAR00011	.163	.485	.412	.110	-.382	.354	.055
VAR00014	.139	.085	.827	.102	.031	.011	.003
VAR00021	-.01	.244	.747	-.182	.297	.018	-.005
VAR00013	.454	-.268	.474	.184	.118	-.277	.011
VAR00002	.047	.107	-.041	.878	.111	.118	.007
VAR00007	.104	.030	.075	.846	.019	.010	-.091
VAR00004	.089	.141	.219	.185	.735	.125	-.101
VAR00010	.123	.049	-.032	-.090	.558	-.090	.522
VAR00012	.148	-.019	-.083	.100	.147	.848	-.007
VAR000016	.145	-.029	.441	.073	-.260	.517	.094
VAR00017	.019	.111	.017	-.011	-.049	.102	.888
VR000008	.505	.365	-.072	.166	.064	.162	-.519

(see Table 1), the lightness level of color combination of the facade, lightness level of the color of openings in the image, the surface area of hues, and the surface area of the openings play a significant role in detecting the weight of the color combination of the facade. The contents of these components are described by the interviewees as follows.

Lightness level of color combination of the facade: The high and low lightness of the hue in the color combination of facade cause it to be recognized as a light and heavy color combination, respectively.

Lightness level of the color of openings (windows) in the image: The color of the opening means the color of the whole opening, i.e., the color of the frame and the glass, and possibly the curtain in its behind, which can be observed in the image. The high and low lightness of the hues of the openings in the facade cause it to be recognized as a light and heavy color combination, respectively.

The area of hues in combination: The large area of the primary hue in color combination helps determine the weight of the color combination of the facade.

The area of openings: The ratio of the area of openings to the area of the whole facade plays a significant role in detecting the lightness/heaviness of the color combination of the facade.

Based on the results, the components affecting the assessment of lightness/heaviness of color combination of the facade can be classified into two categories based on their features, including the ones related to the color features (lightness level of color combination and lightness level of the color of openings in the image) and the components associated with the dimensional features (the area of the hues and the area of openings). These results confirm the lightness/heaviness classification of the color combination of the facade by Cubukcu and Kahraman (2008); thus, the high and low lightness of the combination hues makes the color combination facade look light and heavy, respectively.

The effect of components related to color and dimensional features in assessing the weight of color combination can be explained as follows. The large effect of lightness in evaluating the weight of the color combination of the facade can be explained by the fact that light and dark colors seem lighter and heavier, respectively, which applies to the color combination of the facade. In addition, the effect of the area of hues in assessing the weight of the color combination of the facade can be explained as follows. Based on the laws between form and context, relatively small surfaces seem as shapes and details, while larger ones appear as context and generalities. Therefore, based on Gestalt theory, the image's background color seems visible at first glance, and in fact, the facade is observed with a dominant color. This makes it easy to identify the weight of the dominant monochrome. The color of openings in the image is regarded as a part of the color combination of the facade, the lightness of which affects the weight of the color combination of the facade. The effect of the area of openings in assessing the combination's lightness is since the opening's presence as space makes the facade look light.

Then, the color strip method[7] was used to analyze the colors used in the facade images. To this aim, after simplifying[8] the facade images, the area of each color relative to the total area was plotted in colored strips whose length included 100 units, indicating the percentage of each color in the color combination of the facade. The color strips of selected facade images are shown in Figure 4.

In the next step, a chart was prepared based on the color strip and the codes related to the variables of the HSL color system, which facilitated technical studies on the colors used in the facade in terms of hue, lightness, and saturation. This chart is shown in Figure 5.

Based on the color strips of the selected images of facades related to the area, the facade's main colors (background) include at least 70% of the color area of the facade. Thus, the weight of each color combination equates with the weight of the color, which covers at least 70% of the area of the facade. Based on the HSL codes of the images in which the lightness of hues was considered as a component affecting the assessment

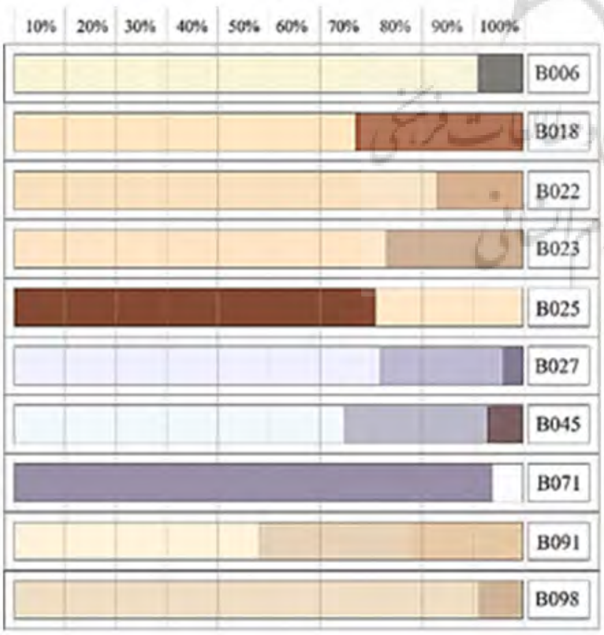

Fig. 4: The color strips of selected images of facades (B006,... are the number of facade's images)

Colour	H	S	L	Area
B006				
	53	13	97	91%
	50	6	40	9%
B018				
	45	14	99	77%
	22	62	75	23%
B022				
	36	23	97	83%
	27	39	82	17%
B023				
	33	22	99	73%
	29	32	78	27%
B025				
	17	60	52	71%
	34	21	99	29%
B027				
	244	6	100	72%
	250	11	82	24%
	260	16	58	4%
B045				
	203	3	98	74%
	240	7	78	19%
	0	20	47	7%
B071				
	261	14	65	94%
	240	1	100	6%
B091				
	40	14	100	48%
	33	20	90	30%
	32	27	90	22%
B098				
	37	17	93	91%
	31	26	81	9%

Fig. 5: The HSL codes of the colors of selected images in assessing the weight of the color combination of the facade

of the weight of the color combination, a color combination was considered as light, in which the lightness level of hues in combination and openings were high (at least 90%). In addition, at least 70% of the facade area had a saturation rate of less than 30 and 5% in facade with warm and cool hues, respectively. Further, the lightness level of hues in combination and openings was less than 65%, considered heavy color combinations.

Furthermore, the results from the color strips and the HSL codes confirm the findings of the Q-method analysis of the data. Therefore, increasing the lightness level of hues in combination and openings creates a light color combination, while reducing makes the color combination look heavy.

CONCLUSION

According to the results, the lightness level of the combination hues, the lightness level of openings' color in the image, the area of hues, and the area of openings in the facade are regarded as the main components in detecting the lightness/heaviness of the color combination of the facade. Thus, the color combination of the facade can be defined and designed as a light and heavy scale based on the components affecting the assessment of the weight of the color combination and obtained quantitative values. To define and classify the color combination of the facade as light, the openings (windows) should constitute at least 30% of the facade area. In addition, at least 70% of the facade area should have a color with a lightness level of more than 90%. Further, the color of the openings should have a lightness level of more than 90%.

Furthermore, the saturation rate of at least 70% of the facade area should be less than 30 and 5% in the facade with warm and cool colors, respectively. To describe the color combination of the facade as heavy, at least 70% of its area should have a lightness level of less than 65%, and the color of the openings should have a lightness level of less than 65%. As shown in the first survey results, weight, temperature, and harmony are also considered to define and classify the color combination of the facade, which has been studied in independent articles. According to the results of these studies, the color combination of the facade can be described and classified based on three emotional scales, temperature-harmony-weight in 8 modes. Based on this classification, it will be possible to quantify the color combination of the facade. In this way, different people can have a unique definition for each color combination of the facade. Using this definition, the facade's color can be classified into eight classifications and evaluated based on it. Using the user evaluation results, it will be determined which of the eight modes of color combination of the facade is preferred by users and is more beautiful in their opinion. Thus, the principles of designing the color combination of the facade can be obtained by using the selected color mode and based on the quantitative definition of that color mode.

In this study, there were limitations such as individual and group differences of participants, the use of southern facade images in the Koy-E-Nasr neighborhood as a representative of real buildings, non-standard measurement tools. Therefore, it is recommended to reexamine these tests by another statistical population, with images of other sides of the facades of different neighborhoods.

ENDNOTES

1. Mehdipour, 2020 & 2021
2. In the Q method, each factor consists of a set of experts with a common point of view on the subject instead of a set of questions (Sepasgar Shahri & Manouchehri, 2014).
3. Nikon Coolpix S2700
4. White reference card is a standard reference in photography to determine light quality. This research used a white A4 paper as a white reference card.
5. H:00, S:0%, L:76%
6. :2180, S:37%, L:76%
7. The color strip method was used by many researchers, such as Tadayon et al. (2018) and O'Connor (2008).
8. Each facade has various components and elements such as the main surface, frames, windows, details, decorations. With different colors. According to the purpose of this study, only the colors of the main elements of the facade were considered in this study.

REFERENCES

AL-Ayash, A., Kane, R. T., Smith, D., & Green-Armytage, P. (2016). The influence of color on student emotion, heart rate, and performance in learning environments. *Color Research & Application,* 41(2), 196-205.

Boeri, C. (2019). An educational experience on the exploration and experimentation of color associations and relationships. *Journal of the international color association,* (24), 1-10.

Boeri, C. (2020). An educational experience about color emotion and its design implications. *Color culture and science journal,* 12(1), 48-56.

Chamaret, C. (2016). Color harmony: experimental and computational modeling. Rennes 1.

Cho, Y. J. (2015). *The New Colour Scales based on Saturation, Vividness, Blackness and Whiteness.* (Doctoral dissertation, University of Leeds).

Cubukcu, E., & Kahraman, I. (2008). Hue, saturation, lightness, and building exterior preference: An empirical study in Turkey comparing architects' and nonarchitects' evaluative and cognitive judgments. Color Research & Application: Endorsed by Inter-Society Color Council, The Colour Group (Great Britain), Canadian Society for Color, Color Science Association of Japan, Dutch Society for the Study of Color, The Swedish Colour Centre Foundation, Colour Society of Australia, *Centre Français de la Couleur,* 33(5), 395-405.

Fang, S., Muramatsu, K., & Matsut, T. (2015). Experimental study of aesthetic evaluation to multi-color stimuli using semantic differential method. *Transactions of Japan Society of Kansei Engineering,* 14(1), 37-47.

Fridell Anter, K. (2000). *What colour is the red house? Perceived colour of painted facades* (Doctoral dissertation, Institutionen för Arkitektur). Retrieved from: http://arkitekturforskning.net/na/article/view/358

García, L., Hernández, J., & Ayuga, F. (2003). Analysis of the exterior colour of agroindustrial buildings: a computer-aided approach to landscape integration. *Journal of Environmental Management,* 69(1), 93-104.

Güneş, E., & Olguntürk, N. (2019). Color-emotion associations in interiors. *Color Research & Application,* 45(1), 129-141.

Guo, F., Li, F., Nagamachi, M., Hu, M., & Li, M. (2020). Research on color optimization of tricolor product considering color harmony and users' emotion. *Color Research & Application,* 45(1), 156-171.

Han, J.-w., Kim, B. G., Choi, I., & Park, S. (2016). Senescent effects on color perception and emotion. *Architectural research,* 18(3), 83-90.

Hanafy, I. M., & Sanad, R. A. (2016). A Cross-cultural study of emotional Responses on Colours. *New Trends and Issues Proceedings on Humanities and Social Sciences,* 2(1), 53–60.

Huang, Ch. (2018). Application and research of color in the façade design of elementary school buildings, in 2nd international conference on art studies: S.E.E. advances in social science, *education and humanities research,* (284), 567-574.

Jalil, N. A., Yunus, R. M., & Said, N. S. (2012). Environmental colour impact upon human behaviour: A review. *Procedia-Social and Behavioral Sciences,* 35, 54-62.

Janssens, J. (2001). Facade colours, not just a matter of personal taste - a psychological account of preferences for exterior building colours. *Nordic Journal of Architectural Research,* 14(2), 17-21.

jewwtt,t. (2020). *HSL: hue, saturation, and light,* retrieved 11Aug 2021, from: https://colortutorial.design/hsb.html

Koo, B., & Kwak, Y. (2015). Color appearance and color connotation models for unrelated colors. *Color Research & Application,* 40(1), 40-49.

Kuang, Y., & Zhang, W. (2017, December). The Application of Color in Interior Design. *In 4th International Conference on Education, Language, Art and Intercultural Communication* (ICELAIC 2017) (pp. 645-647). Atlantis Press.

Li, K. R., Yang, Y. Q., & Zheng, Z. Q. (2020). Research on color harmony of building façades. *Color Research & Application,* 45(1), 105-119.

Liu, T., Hutchings, J., & Luo, M. R. (2020). A method for scaling impressions of a scene. Color Research & Application, 45(5), 846-861.

Manav, B. (2017). Color-emotion associations, designing color schemes for urban environment-architectural settings. *Color Research & Application,* 42(5), 631-640.

McLachlan, F. (2013). *Architectural colour in the professional palette. Routledge.* Retrieved from: https://www.routledge.com/Architectural-Colour-in-the-Professional-Palette/McLachlan/p/book/9780415597098

Mehdipour, M., Ekhlassi, A., Yazdanfar, S., & SalehSedghpour, B. (2021). Determining the components affecting the assessment temperature dimension of the color combination in Residential buildings exterior. *International Journal of Architecture and Urban Planning (IJAUP),* 31(1),1-17.

Mehdipour, M., Yazdanfar, A., Ekhlasi, A., & Saleh Sedghpour, B. (2020). Determining the Components Describing the Harmony-Contrast of the Color Combination in Residential Buildings Exterior. *IJAUP,* 31(1), 1-17.

Naz, A., Kopper, R., McMahan, R. P., & Nadin, M. (2017, March). Emotional qualities of V.R. space. *In 2017 IEEE virtual reality* (V.R.) (pp. 3-11). IEEE.

O'Connor, Z. (2008). *Façade colour and aesthetic response: Examining patterns of response within the context of urban design and planning policy in Sydney.* Academic dissertation for the degree of Doctor of Philosophy, University of Sydney. Retrieved from: https://core.ac.uk/download/pdf/41232383.pdf

Odabasioglu, S. (2015). *Effect of area on color harmony in interior spaces.* Ph.D. dissertation of department of interior architecture and environmental design Ihsan Dogramaci Bilkent University, Ankara.

Ou, L. C., Yuan, Y., Sato, T., Lee, W. Y., Szabó, F., Sueeprasan, S., & Huertas, R. (2018). Universal models of colour emotion and colour harmony. *Color Research & Application,* 43(5), 736-748.

Palmer, S. E., & Schloss, K. B. (2015). Color preference. *Encyclopedia of color science and technology,* 1-7.

Prado-Leon,L.R., Zambrano-Prado,P.L., Herrada-Rodriguez,S. & Felizardo-Gomez, S. (2018). Color preferences for private and semi-private areas in hotels. *Universal journal of psychology,* 6(4), 113-120.

Rostami, M., Izadan, H. & Mahyar, F. (2015). Color emotion models. CIELAB color coordinates, and Iranian emotional responses, *Journal of textiles and polymers,* 3(2), 46-54.

Santosa, H., & Fauziah, N. (2017). Aesthetic evaluation of restaurants facade through public preferences and computational aesthetic approach. *IPTEK Journal of Proceedings Series,* 3(3), 31-40.

Sarıca, C., & Cubukcu, E. (2018). Evaluating color combinations using abstract graphics versus pictures of simulated urban settings. *A| Z I.T.U. J Fac Archit,* 15(1), 123-134.

Savavibool, N., Gatersleben, B., & Moorapun, C. (2018). The effects of colour in work environment: A systematic review. *Asian Journal of Behavioural Studies,* 3(13), 149-160.

Sepasgar Shahri, M., & Manouchehri, M. (2014). Identifying the viewers' mentality of the series "Pahlavi Hat" with "Q method." *Journal of Communication Research*, 21(2), 113-134.

Shinomori, K., Komatsu, H., & Negishi, I. (2020). Bidirectional relationships between semantic words and hues in color vision normal and deuteranopic observers. *JOSA A,* 37(4), A181-A201.

Shinomori,K., and Komatsu,H. (2018). ¬Semantic word impressions expressed by hue. *Journal of the optical society of America A,* 35(4), -B55—B65.

Slobodenyuk, N., Jraissati, Y., Kanso, A., Ghanem, L., and Elhajj, I. (2015). Cross-model associations between color and haptics. *Atten percept psychophys,* 77, 1379-1395.

Sokolova,M.V., and Fernandez-Caballero,A. (2015). A review on the role of color and light in affective computing. *Applied sciences,* 5(3), 275-293.

Tadayon, B., Ghalenoee, M., & Aboee, R. (2018). Proposing a method for analyzing the color façade and adopting it as pattern in historic urban spaces' scape case study: Naghsh-e Jahan square of Isfahan. *Bagh-e Nazar,* 15(59), 47-60.

Takaneh, Y. & Ferguson, G. (2011). *Statistical analysis in psychology and educational sciences.* Tehran: Arasbaran.

The Institute of Social Studies and Research. (2015). Cultural, Social and identity typology of Tehran neighborhoods, Tehran urban research & planning center. Retrieved from: https://rpc.tehran.ir/en/

Wardono, P., Hibino, H., & Koyama, S. (2017). Effects of Restaurant Interior Elements on Social Dining Behavior. *Asian Journal of Environment-Behaviour Studies*, 2(4), 43-53.

Weingerl,P., and Javorsek,D. (2018). Theory of harmony and its application. *Technical Gazette,* 25(4), 1243-1248.

Zareh, A., & Lotfi, K. (2017). Color in the city with the approach of creating diversity and vitality in the urban environment, *Journal of research and urban planning,* 8(28), 99-110.