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RESEARCH ARTICLE

Assessing architectural color preference after Le Corbusier's 1931 Salubra keyboards: A cross cultural analysis

Juan Serra [a,*], Banu Manav [b], Yacine Gouaich [c]

[a] Department of Architectural Graphic Expression, Escuela Técnica Superior de Arquitectura, Universitat Politècnica de València, Valencia, 46022, Spain
[b] Department of Interior Architecture and Environmental Design, Faculty of Art and Design, Kadir Has University, Istanbul, 34083, Turkey
[c] Laboratory LCTPE, University Abdelhamid Ibn Badis, Mostaganem, 27000, Algeria

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Abstract Color preference for the interior of a bedroom of Le Corbusier's Swiss Pavilion was studied using 1931 Salubra color keyboards in a cross-cultural analysis. Results indicate that students from architecture and interior design slightly dislike or are indifferent to Le Corbusier color combinations and prefer pale and low saturated colors for interior architecture. The least preferred colors belong to green and brown hues. Scarce significant gender differences are found that follow a stereotyped tendency, with females preferring pinks, light blues and light greens, while males vivid oranges and Vermilions. Near Easterners are significantly more likely to green colors, while Western Europeans to dark greys. These data indicate that not only hue, but also value and saturation are important color features to inform preference for interior architecture.

1. Introduction

Color is an important feature for the configuration of interior architecture and inhabitants well-being (Schloss and Palmer, 2009), but considerations about color preferences in buildings have been a difficult issue to be addressed by professionals (Serra Lluch, 2019). Color preference seems to be dependent upon the personal

* Corresponding author.
E-mail addresses: juanserra@ega.upv.es (J. Serra), banu.manav@khas.edu.tr (B. Manav), yacine.gouaich@gmail.com (Y. Gouaich).
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characteristics (Bakker et al., 2015) and the psychophysical structure (Manav, 2017). When colors are displayed in interiors, the spatial color experience scheme is compiled not just by biological reactions to color stimuli, but also by the expected activity to be developed in such an interior (Torres et al., 2020), rooted in collective unconscious, conscious symbolism and association, personal factors, trends, fashion and style (Meerwein, 2007). The ecological valence theory (Schloss and Palmer, 2009) states that color preferences reflect people's cumulative emotional responses to environmental objects or events strongly associated with particular colors. People's particular aesthetic responses to colors are caused by their affective responses to objects and situations associated with that color (Strauss et al., 2013). Therefore, color preferences should be evaluated within a context.

The debate about whether gender and culture play a role in color preference has been a question of interest. Some authors state that gender differences in color preference rely on the "cone-contrast theory", which posits a physiological explanation based on the two fundamental neural dimensions that underlie color coding in the human visual system (Hurlbert and Ling, 2007), but later findings cannot demonstrate this theory (Al-Rasheed, 2015). Al-Rasheed (2015) investigated variations in color preference for both Arabic and English speakers obtaining different preference curves between both groups, yet there was greater similarity for Arabic and English males than Arabic and English females. Some studies (Camgöz et al., 2002; Ou et al., 2004), have shown no significant gender differences in hue preference, while others (Burkitt et al., 2003) reported that girls significantly preferred pink, purple, and red more than boys. On the other hand, boys showed greater preference than girls for black, blue, brown, green, and white. Similarly, Hurlbert and Ling (2007), tested gender effect on color preferences and reported that females prefer reddish hues and dislike greenish-yellowish hues significantly more than males.

Because colors have different meanings in different cultures, it is worthy to consider geographical and cultural proximity for color preferences. As Saito (1996) reported, in Asia there is a common preference for white with its associative image such as being clean, pure, harmonious and refreshing. Hurlbert and Ling (2007) reported that cultural factors played a role in differences in the color preference of English and Chinese participants, with Chinese having a stronger preference for reddish hues compared to English. More recently, Jonauskaite et al. (2019) tested the cross-modal correspondence in the physical environment we live in. The yellow-joy associations of 6625 participants from 55 countries were investigated and how yellow-joy associations varied geographically, climatologically, and seasonally were discussed. Participants who live further away from the equator and in rainier countries are more likely to associate yellow with joy. Similarly, in architecture, Kaya and Crosby (2006) indicate that the emotional associations about certain colors have an influence in the color preference for different building types. Hence, many participants linked blue with relaxation, calmness, comfort and peace; and so blue was mostly associated with residences (22.4%, n 22). Van Der Voordt et al. (2017) explored color preference in four different types of interior spaces with 1077 Dutch people. They found that, apart from white that was reported the most preferred color for all interiors; no other single color was preferred by more than 10% of the respondents, nor for the office and meeting rooms, nor for the living room and bedroom. More recently, Ulusoy et al. (2020) explored color meanings in interiors of residential architecture (eg., bedrooms) with 14 adjectives (eg., comfortable, pleasant) and demonstrated that color associations with negative meanings have low variations among residential interiors, while positive adjectives are more dependent on the interior type.

In literature, we have few cases of renewed architects who have set their color preferences for interiors. The case of Le Corbusier is noteworthy, not just for being one of the masters of the Modern Movement, but also for setting his color preferences as early as the 1930's, a period which has often been misunderstood as having just white buildings (Serra Lluch, 2010). In 1932, Le Corbusier selected 43 colors for the wallpaper company Salubra, and displayed them in a similar way to the distribution of the sounds in a piano, in 12 "color keyboards" that he considered appropriate for architecture (Caivano, 2007; Serra et al., 2016). As we learn from the manifesto *Polychromie Architecturale* by Le Corbusier (1932, In Le Corbusier and Rüegg, 1997: 97), the criteria for the combination of these colors was rooted in his personal preferences. The contribution of Le Corbusier to the history of architectural color is very important, and has many cultural implications, because his legacy is on the roots of the way in which we understand and conceive architecture nowadays. Le Corbusier conceptualized the architectonic color in three main ideas: 1) color modifies space, 2) color classifies objects, and 3) color acts physiologically upon us and reacts strongly upon our sensitivities (Le Corbusier, 1932; In Le Corbusier and Rüegg, 1997). The two first concepts, related to the formal features of architecture, were trained by Le Corbusier himself in his buildings, and have been studied by later researchers (Serra et al., 2016; Heer, 2009; Caivano, 2007; Le Corbusier and Rüegg, 1997). On the contrary, the question about psychology has received less attention and there are no analysis of color preferences after Salubra keyboards in interior architecture.

Therefore, the main objective of this study is to investigate actual color preferences for the interior of bedrooms, after Le Corbusier's 1931 *Salubra Claviers* in a cross-cultural analysis, exploring perception differences between two cultural groups (Western Europe and Near East) and between genders. To that aim, the interior of a bedroom from the Swiss Pavilion (Le Corbusier, 1930—1931) is chosen as a case study.

2. Materials and methods

The color combinations were taken from the 12 Salubra 1931 Keyboards. Participants chose one keyboard and assessed the preference for 26 bedrooms with the colors of that keyboard on a Likert scale. We analyzed the preference for each bedroom (312 samples), keyboard (12 samples), and individual colors (43 samples) separately. We

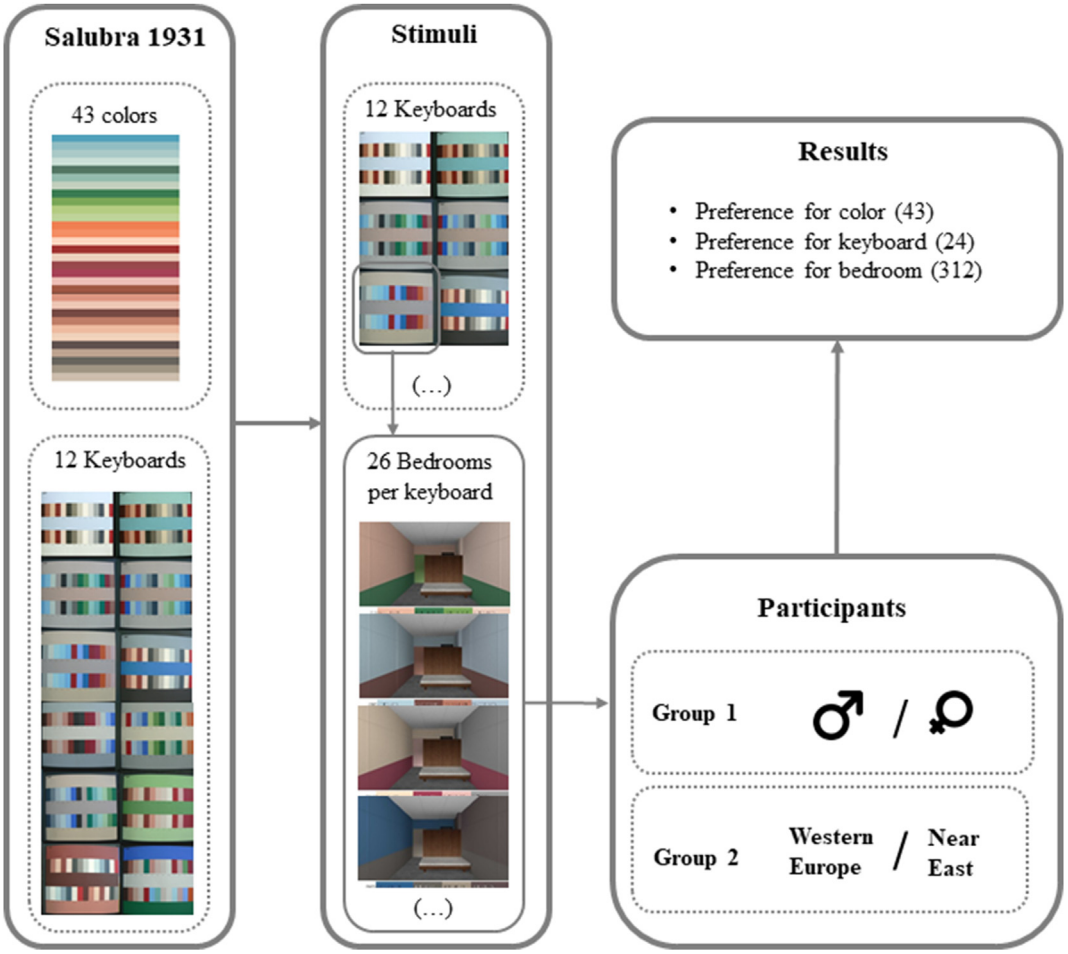


Fig. 1 Methodology scheme.

compared groups with different cultures (Western Europe and Near East) and gender (Fig. 1).

2.1. Stimuli

The stimuli are virtual renderings of an original bedroom from the Swiss Pavilion (1930—1931), a student's residence in *Cité Internationale Universitaire* in Paris, with different color combinations. It is one of the most important buildings designed by Le Corbusier to experiment his theories on collective housing and to use his philosophy "machine to live in", in collaboration with Charlotte Perriand for the interior design (Curtis, 1981). Moreover, the construction of this building is contemporary to *Polychromie Architecturale* and there is evidence that Le Corbusier worked with the Salubra wallpapers for the interiors (Heer, 2009). In the study, a sketch drawn by Le Corbusier is reproduced, with a frontal conic perspective and the observer standing in the center of the bedroom looking to the entrance, and with the same indications for the color distribution: the ceiling white; the floor with a gray or brown linoleum, the background colors (*valeurs de fond*) on the walls and the color accents (*couleurs tons*) on secondary elements. A base image in grayscale was generated with a 3D model using Autodesk Revit Architecture and the geometric information available in the publication *Le Corbusier Ouvre Complete* (Boesiger, 2015). The lighting for the virtual model was set as a D65 illuminant, coming from the exterior of the building through the glass facade, thus from the back of the observer. The grayscale base image obtained was edited 312 times to incorporate all the color combinations in an underlying layer, with the software Adobe Photoshop, that assured the exactitude of the colors displayed. The color space selected was sRGB, which has a limited gamut but is the standard for a reliable web reproduction. The original Salubra colors were measured in Le Corbusier's Foundation in Paris with a NCS Colorimeter, and translated into sRGB with the NCS Navigator Tool (https://ncscolour.com/).

The color combinations for the bedrooms come from 43 individual colors, set in the 12 color keyboards *Espace*, *Ciel*, *Velour I* and *II*, *Mur I* and *II*, *Sable I* and *II*, *Paysage*; *Bigarré I*, *II* and *III*. In each keyboard, the final user can isolate the colors in groups of 4, having 2 *valeurs de fond* and 2 *couleurs tons* (Fig. 2). The 43 individual colors derive from 14 main colors. By adding white pigment to each of these main colors, Le Corbusier obtained different nuances that belong to the same pigment-hue family (Serra et al., 2016). In the original Salubra collection, the colors were denoted by a three-digit number, the units approximately indicate the color nuance with a 0 for the main color, whereas the tens

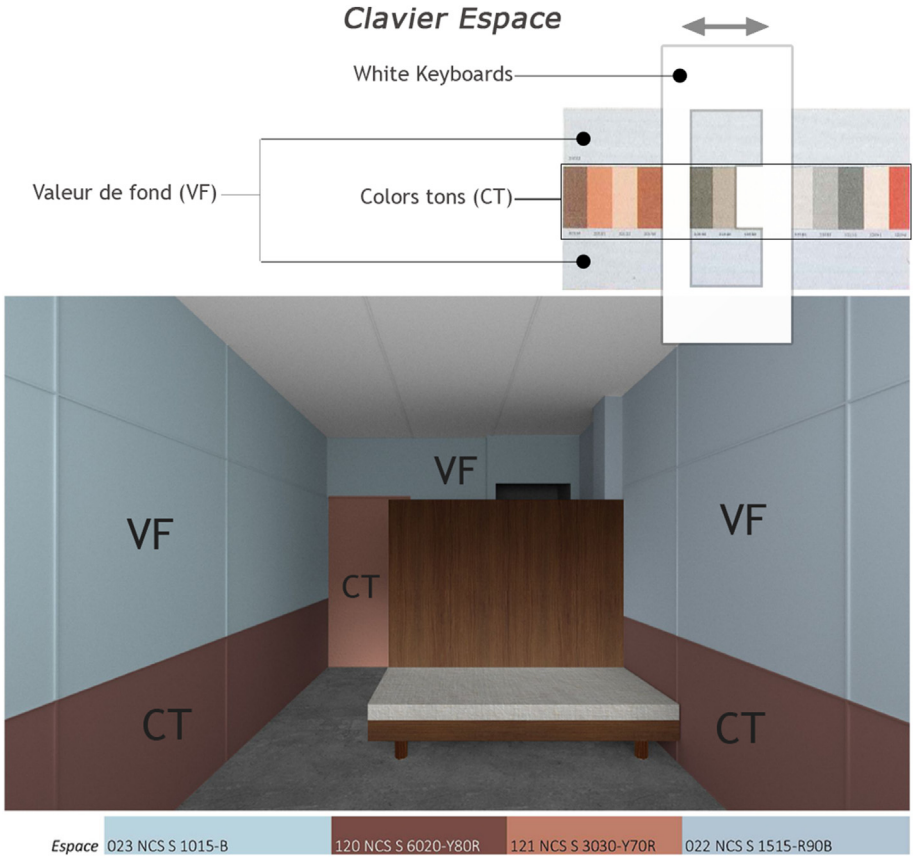


Fig. 2 Example of a combination of four colors from the keyboard *Espace*, applied into the virtual room. CT = *Color ton*, VF = *Valeur de fond*.

and hundreds identify each of the 14 pigment—hue families. Following Colli's (1987) designation, the pigment-hue families are: White (first two digits 00: 001), Grays (01: 010, 011, 013), Ultramarine-blues (02: 020, 021, 022, 023, 024), Cobalt-blues (03: 030, 031, 032, 033, 034), Veronese-greens (04: 040, 041, 042), Yellowish-green (05: 050, 051, 052, 053); Yellow-Ochre (06: 060); Oranges (08: 080, 081, 081), Vermilion-reds (09: 090, 091), Carmine-reds (10: 100, 101, 102), Red-Ochre (11: 110, 111, 112); Sienna (12: 120, 121, 122, 123), Brown (13: 130, 131), and Shadows (14: 140, 141, 142, 150). The total amount of possible 4 color combinations in Salubra keyboards is 312, 26 per keyboard, so this is the number of different images of the bedroom in the experiment. We labeled each image with a number that corresponds with the order of such a color combination in the Salubra Keyboards.

2.2. Questionnaire

The questionnaire was completed via a website (https://lecorbusiercolors.blogs.upv.es/). Firstly, personal information was recorded with the following questions; "where are you from?"", "how old are you?", "what's your gender?". Secondly, color preference was asked after this explanation: "You will be asked to assess your color preference for a bedroom from the Swiss Pavilion (Le Corbusier, 1931—1933) with 26 variations, following Le Corbusier's Salubra Color Keyboards. Please note that the scale of assessment is set as follows: 1-Dislike extremely, 2-Dislike moderately, 3-Dislike slightly, 4-Neither Like nor Dislike, 5-Like slightly, 6-Like moderately, 7-Like extremely". Then the participant was asked to "Select the color keyboard you prefer" by clicking on any of the 12 images of the Salubra Keyboards that appeared on the screen randomly. Each participant evaluated the 24 bedrooms from the selected keyboard, which appeared one after the other randomly, answering the question "I like this color combination … " on a Likert Scale from 1 to 7.

The participants were recruited via online questionnaire sent by email to students in the School of Architecture in Universitat Politècnica de València (Spain), the Faculty of Art and Design in Kadir Has University in Istanbul (Turkey), and the School of Architecture in Mostaganem (Algeria). In each university, all the participants were enrolled in a subject related with color and interior design. Previously to the survey completion and during the course, students had already tested their color accuracy and possible color blindness with an online version of the Munsell Color Vision Hue Test (http://xritephoto.com/cool-tools) and the Ishihara's color vision test (http://www.dfis.ubi.pt/). Students had also checked the color calibration of their reproduction devices, personal laptops, with specific hardware for color management (i1 Pro X-Rite). However, it was not possible to have a complete control of the lighting conditions of the room in which participants completed the survey. This is a limitation of the study that

we assumed in order that students completed the survey at their ease, particularly during the Covid-19 lockdown.

2.3. Participants

The sample included 644 participants (388 females, 60.2%; 256 males, 39.8%) from various countries in Western Europe and Near East (250 WE, 38.8%; 394 NE, 61.1%), aged between 18 and 25 years old (mean = 20,5). In the group of Western Europe the countries of origin were: Spain (214, 33.75%), Italy (15, 2.37%), Poland (13, 2.05%), Belgium (5, 0,63%) and Portugal (3, 0,47%). In the group of Near East the countries of origin were: Turkey (327, 50.16%), Algeria (56, 8.83%), Bulgaria (3, 0.47%), Morocco (3, 0.47%), Siria (3, 0.47%), Iran (2, 0.32%).

2.4. Data preparation and statistical analyses

We used an anonymized database with IBM SPSS® software. The statistical tests were run for the descriptive analysis for the preference of the bedrooms, the keyboards and individual colors. We also analyzed color perception differences between groups, culture and gender separately via bedroom images, keyboards, and individual colors. To analyze significant differences in one factor segmented into two groups, we used the independent samples Student's t-test. To check the homogeneity of variance we performed Levene's test.

- The preference for each individual bedroom image (312) was calculated as the mean value of the assessments for that specific bedroom
- The preference for each Keyboard (12) was calculated as the mean value of the assessments for the 26 bedrooms with color combinations belonging to that keyboard.
- The preference for each individual color (43) was calculated as the mean value of the assessments for every bedroom containing that color as a *valeur de fond* or a *couleur ton*. It is important to note that the recurrence of each color is different and relies on the number of times that Le Corbusier used that single color in any of the keyboards. Certainly, the v*aleurs de fond* are the most numerous, as they belong at least to the 13 color combinations of the same keyboard.

3. Results

3.1. Results of the descriptive analysis

3.1.1. Color preference for bedroom images

The 312 bedroom images receive a mean value between 2.13 (2-Dislike Moderately) and 4.71 (5-Like Slightly), with a global Mean Value = 3.6 (4- Neither Like nor Dislike). Results show that 23.7% (N = 74) are liked (MV $\geq$ 4.00), while 68% (N = 213) are disliked slightly (3 $<$ MV $\leq$ 4), and 9.2% (N = 25) are disliked moderately (2 $<$ MV $\leq$ 3). In an order from the most to the least preferred, the preference for bedrooms follows a linear tendency. Nevertheless, 25 of the bedrooms are preferred over this lineal tendency (MV $\geq$ 4.28) and 14 are least preferred, with a drop in relation with this lineal tendency (MV $\leq$ 2.81) (Fig. 3). Figs. 4 and 5 respectively show the 10 most and least preferred bedrooms in order.

3.1.2. Color preference for keyboards

The preference for the 12 color keyboards received a mean value between 3 (dislike slightly) and 4 (neither like nor dislike). Fig. 6 indicates the keyboards in order of preference, with the three least preferred keyboards corresponding to the group of *Bigarré*.

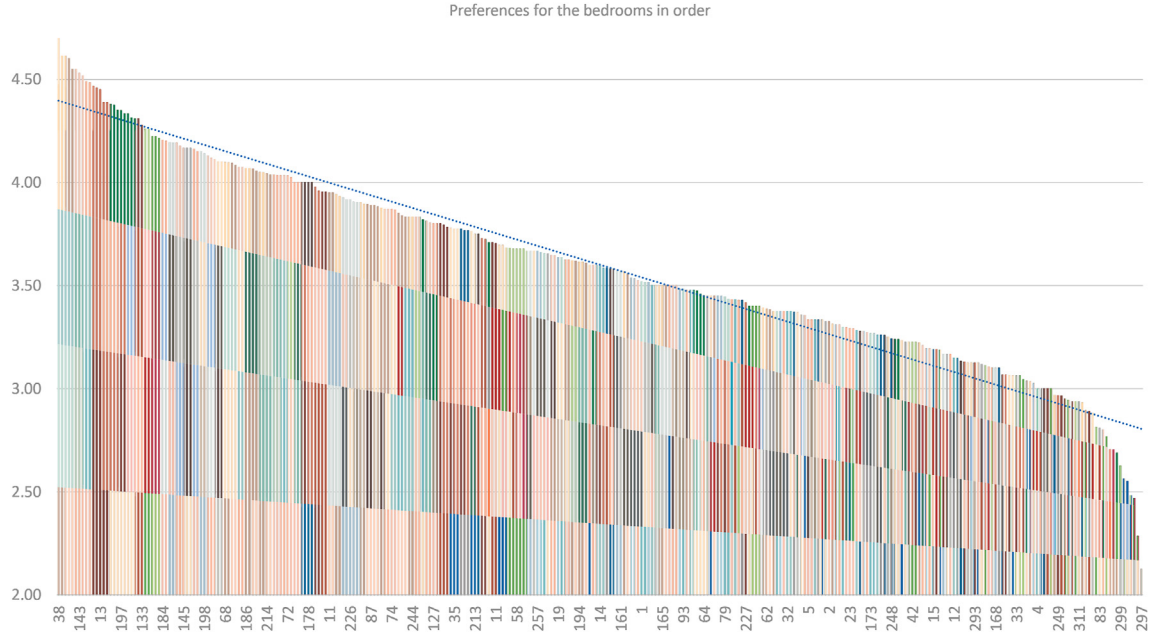


Fig. 3 Mean value of the preference for the 312 bedrooms, in order from the most to the least preferred.

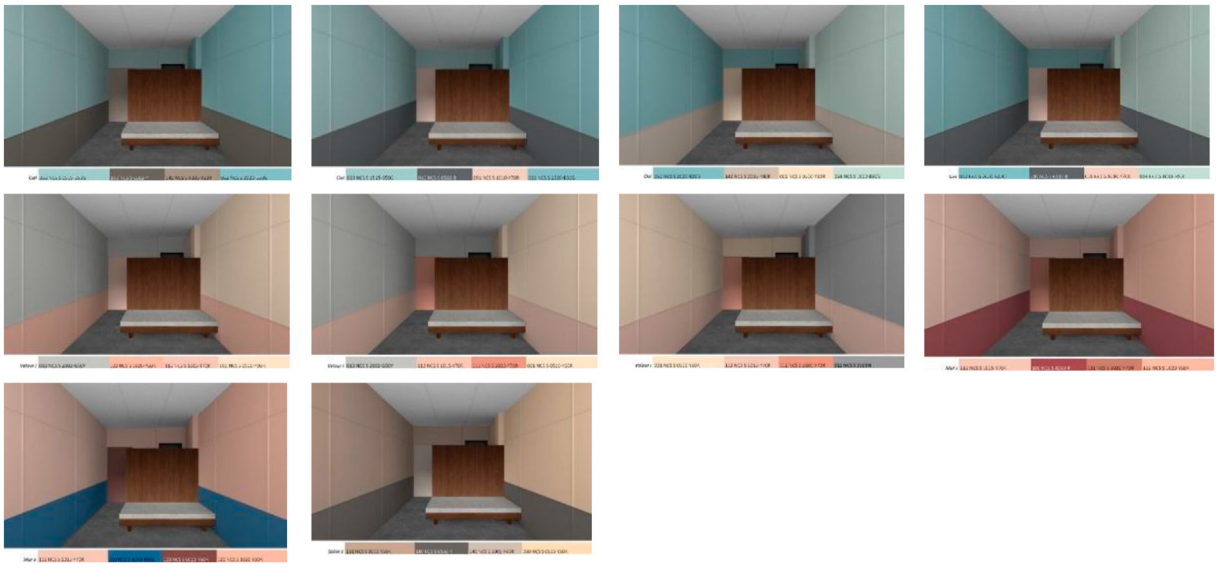


Fig. 4 The 10 most preferred bedroom images.

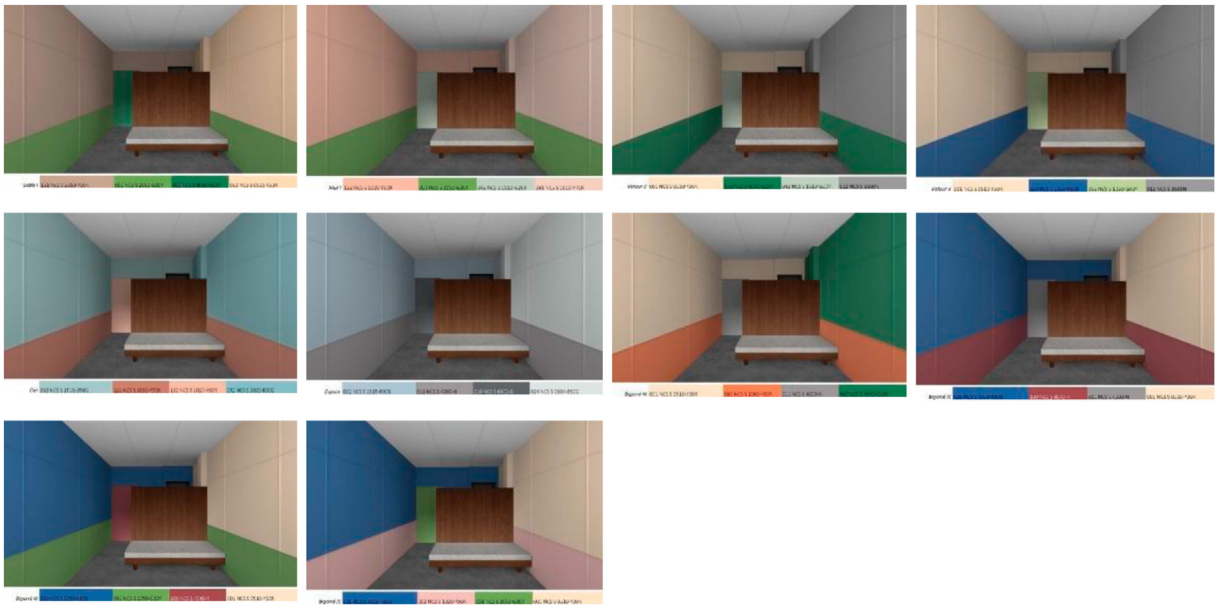


Fig. 5 The 10 least preferred bedroom images.

3.1.3. Color preference for the 43 individual Salubra colors

The individual colors received a mean value between 2.66 (2-Dislike moderately), and 3.96 (4-Neither Like nor Dislike), with an average of 3.57 (3-Dislike slightly). In an order from the most to the least preferred, they follow a linear tendency with a clear drop in the last four colors that have a preference equal to or under 3.28: Sal 020 (MV = 3.28), Sal 053 (MV = 3.28), Sal 051 (MV = 3.14), Sal 001 (MV = 3.14), Sal 050 (MV = 3.05), and Sal 042 (MV = 2.66) (Fig. 7). Coherently, the presence of these colors reduces the preference for that bedroom image: Sal 001 appears in 78 combinations in *Velour I* and *II*, and *Bigarré III* (the least preferred keyboard); Sal 050 in 13 combinations in *Bigarré III*; Sal 051 in 26 combinations in *Paysage*; Sal 053 in 13 combinations in *Paysage;* and Sal 020 in 13 combinations in *Bigarré III*. On the contrary, the 6 most preferred colors belong to the Cobalt-Blues, Grays and Shadows: Sal 142 (MV = 3.96), Sal 031 (MV = 3.93), Sal 010 (MV = 3.85), Sal 033 (MV = 3.84), Sal 140 (MV = 3.79) and Sal 034 (MV = 3.79). The color Sal 033 being a *valeur de fond* in keyboard *Ciel*.

The presence of those colors that are "main colors" for each pigment-hue family entails a lower preference (MV $\leq$ 3.6): Yellowish-green (Sal 050), Ultramarine-blue (Sal 020), Vermilion-red (Sal 090), Red-Ochre (Sal 110),

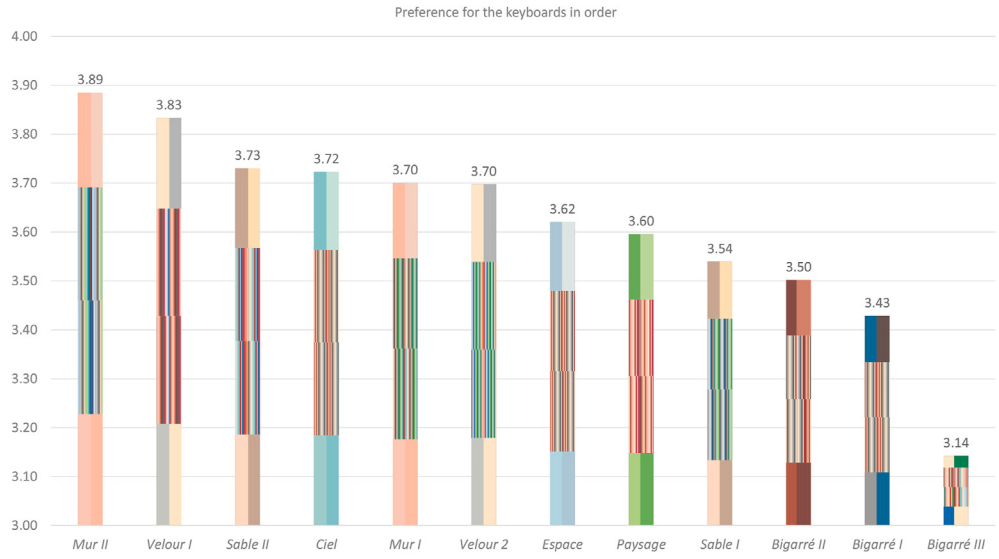


Fig. 6 Mean preference for the 12 Salubra keyboards in order, from the most to the least preferred.

Carmine-red (Sal 100), Veronese-green (Sal 040), Cobalt-blue (Sal 030), and Orange (Sal 080). Participants prefer a "softer" version of these main colors, when they are mixed with white to obtain lighter and less saturated colors. This rule does not apply to the main colors of those pigment hue families which are more neutral, and so with lower saturation: Gray (Sal 010), Shadows (Sal 140), Yellow-Ochre (Sal 060), Brown (Sal 130), and Sienna (Sal 120); all of them with a MV $>$ 3.6. Therefore, the saturation of a color seems to be a key feature in color preference for a bedroom image. Green hues seem to be an exception, as the presence of softer versions of the main color pigments Veronese-Green (Sal 042) and the complete hue-family of Yellowish-Greens (Sal 052, and particularly Sal 051 and Sal 053), directly entail a lower preference for such a bedroom image.

3.2. Results of preference differences between genders

There are significant differences between genders in preference for 16.6% (N = 2) of the color keyboards: *Espace* [Sig. (2-tailed) = 0.008 $<$ 0.05] and *Mur I* [Sig. (2-

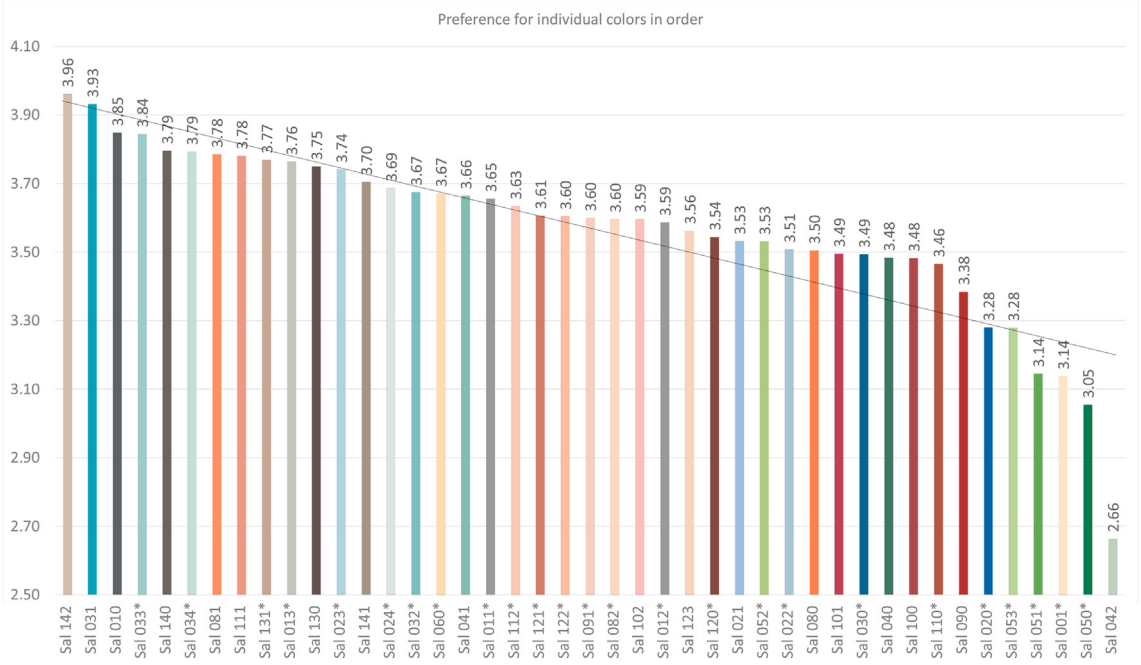


Fig. 7 Mean preference for the 43 individual Salubra colors in order from the most to the least preferred (*Asterisk indicates that the color is a *valeur de fond* in any of the keyboards).

Table 1 Mean of the responses, standard deviation and standard error for the keyboards with significant differences between genders, *Espace* and *Mur I*.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Espace	Female	53	3.492264	0.9521769	0.1307916
	Male	26	3.940769	0.5153789	0.1010741
Mur I	Female	25	3.892800	1.1383011	0.2276602
	Male	16	3.328125	0.4303676	0.1075919

tailed) = 0.0032 < 0.05]. Males significantly preferred *Espace* compared to females, while females significantly preferred *Mur I* compared to males (Table 1).

Regarding the preference for the 312 bedroom images, as we found gender differences in *Espace* and *Mur I*, we analyzed bedrooms with color combinations belonging to these two keyboards (numbers 1 to 26, 105 to 130 respectively). There are significant differences between genders in preference for 5% (N = 16) of the bedroom images (P < 0.05). Table 2 shows these bedrooms in order, from the most to the least differences between females and males. Despite these differences between genders, the two most preferred bedrooms for males and females in each keyboard are coincident: 117, 121, 12 and 15.

Regarding the preference for the 43 individual Salubra colors, we find significant differences between genders for 20.1% (N = 9, P < 0.05): Sal 023, Sal 102, Sal 041, Sal 034, Sal 122, Sal 040, Sal 032, Sal 090 and Sal 081. Fig. 8 shows the Salubra colors in order, from the most to the least differences between females and males. Females prefer pale blues (Sal 023, Sal 034), pale green (Sal 041) and pink (Sal 102), lighter and less saturated colors in general. Males opt for more saturated colors in orange (Sal 081), Vermilion-red (090), and darker versions of blues (Sal 032). The color green Sal 040 is an exception, despite being the darkest and most saturated color in the Veronese-Green hue family, it is more preferred by females than males.

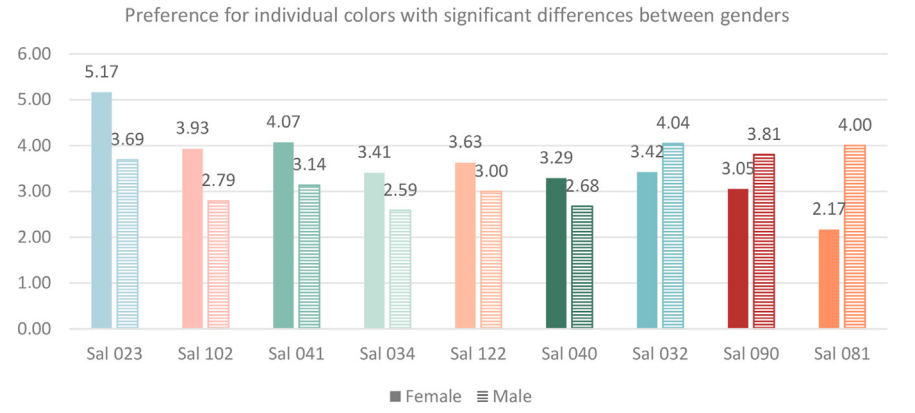
If we analyze separately the most preferred individual Salubra colors for females, just a few of them have a mean value equal or over 4 ("neither like nor dislike"): Sal 023 (MV = 5.17), Sal 031 (MV = 4.25), Sal 142 (MV = 4.17), Sal 041 (MV = 4.07), and Sal 140 (MV = 4.04). For males, the most preferred individual Salubra colors are Sal 033 (MV = 4.19), Sal 013 (MV = 4.18), Sal 022 (MV = 4.1), Sal 140 (MV = 4.09), Sal 032 (MV = 4.04) and Sal 081 (MV = 4.00). Therefore, the pale blue color Sal 023 is the only one that receives a rating in color preference over 5 ("Like slightly"), and just for the group of females.

3.3. Results of perception differences between cultures

There are significant differences between cultures in preference for 41.6% (N = 5) of the color keyboards: *Mur I* [Sig. (2-tailed) = 0.031 < 0.05], *Paysage* [Sig. (2-tailed) = 0.002 < 0.05], *Bigarré I* [Sig. (2-tailed) = 0.004 < 0.05], *Bigarré II* [Sig. (2-tailed) = 0.038 < 0.05] and *Bigarré III* [Sig. (2-

Table 2 Color preferences in bedrooms with significant differences between genders. In order from the most to the least difference in each keyboard. Bold numbers indicate the most preferred bedrooms.

Bedroom	*Keyborad*	*Valeur de fond 1*	*Ton de Couleur 1*	*Ton de Couleur 2*	*Valur de fond 2*	*Female*	*Male*	*Diff*
117	*Mur I*	Sal 112	Sal 100	Sal 121	Sal 122	**5.26**	**3.38**	1.89
121	*Mur I*	Sal 122	Sal 131	Sal 130	Sal 091	**4.35**	**3.13**	1.22
114	*Mur I*	Sal 112	Sal 042	Sal 041	Sal 122	3.87	2.67	1.20
127	*Mur I*	Sal 122	Sal 042	Sal 041	Sal 091	4.26	3.06	1.20
128	*Mur I*	Sal 122	Sal 041	Sal 040	Sal 091	3.82	2.63	1.19
111	*Mur I*	Sal 112	Sal 141	Sal 050	Sal 122	3.85	2.88	0.98
115	*Mur I*	Sal 112	Sal 041	Sal 040	Sal 122	3.35	2.38	0.97
130	*Mur I*	Sal 122	Sal 100	Sal 121	Sal 091	**4.74**	**4.00**	0.74
17	*Espace*	Sal 022	Sal 110	Sal 112	Sal 024	3.10	4.71	-1.61
1	*Espace*	Sal 023	Sal 120	Sal 121	Sal 022	3.00	4.33	-1.33
4	*Espace*	Sal 023	Sal 110	Sal 112	Sal 022	3.26	4.56	-1.29
14	*Espace*	Sal 022	Sal 120	Sal 121	Sal 024	3.25	4.37	-1.13
26	*Espace*	Sal 022	Sal 091	Sal 090	Sal 024	3.08	4.11	-1.04
12	*Espace*	Sal 023	Sal 010	Sal 091	Sal 022	**3.98**	**4.96**	-0.98
25	*Espace*	Sal 022	Sal 010	Sal 091	Sal 024	**3.92**	**4.85**	-0.93
13	*Espace*	Sal 023	Sal 091	Sal 090	Sal 022	3.23	4.11	-0.88



Preference	*Sal 023*	*Sal 102*	*Sal 041*	*Sal 034*	*Sal 122*	*Sal 040*	*Sal 032*	*Sal 090*	*Sal 081*
Difference female-male	1.47	1.14	0.94	0.82	0.63	0.61	-0.62	-0.75	-1.83

Fig. 8 Color preferences for individual Salubra colors with significant differences between genders in order from the most to the least difference.

Table 3 Mean of the responses, standard deviation and standard error for the keyboards with significant differences between cultures, *Paysage* and *Bigarré I*.

	Culture	N	Mean	Std. Deviation	Std. Error Mean
Mur I	Near Eastern	19	4.017368	0.9423896	0.2161990
	Western European	22	3.374545	0.8941062	0.1906241
Paysage	Near Eastern	32	3.933125	0.7695136	0.1360321
	Western European	13	2.643077	1.1868332	0.3291683
Bigarré I	Near Eastern	41	3.591463	0.8915284	0.1392333
	Western European	21	3.075238	0.4843823	0.1057009
Bigarré II	Near Eastern	52	3.713654	1.1227173	0.1556929
	Western European	20	3.088000	1.1265625	0.2519070
Bigarré III	Near Eastern	21	3.343333	0.9811184	0.2140976
	Western European	9	2.142222	1.3075242	0.4358414

tailed) $=0.01$ <0.05]. Near Easterners significantly prefer these 5 color keyboards compared with Western Europeans (Table 3).

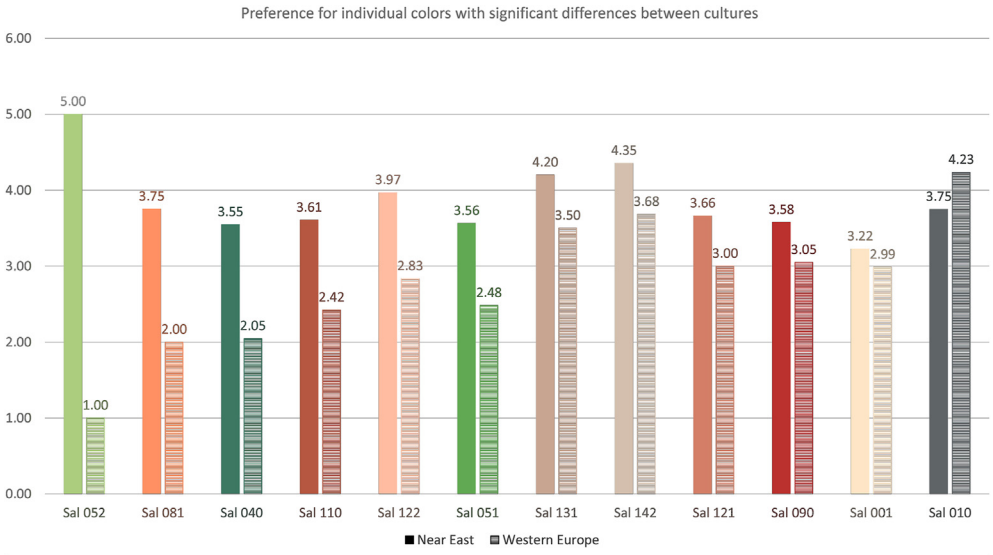
Regarding the preference for the 312 bedroom images, as because we found cultural differences in 5 keyboards, we analyzed bedrooms with color combinations belonging to these color keyboards (numbers 105 to 130, 209 to 312). There are significant differences between cultures in preference for 18.3% ($N = 57$) of the bedroom images ($P < 0.05$). All of them are more preferred by Near Easterners than Western Europeans. Table 4 shows these bedrooms in order, from the most to the least difference between Near Easterners and Western Europeans, in each keyboard. In general terms, participants from Near East significantly like these bedrooms with a mean value of 3.9 ("4- Neither Like nor Dislike"), while in Western Europe this mean value drops to 2.41 (2-Dislike moderately). Despite these differences between cultures, the two most preferred bedrooms for both cultures in each keyboard are coincident, except for bedrooms 210 and 214 (*Paysage*), and 283 (*Bigarré II*).

Regarding the preference for the 43 individual Salubra colors, we find significant differences between cultures for 28% ($N = 12$, $P < 0.05$): Sal 001, Sal 010, Sal 040, Sal 051, Sal 052, Sal 081, Sal 090, Sal 110, Sal 121, Sal 122, Sal 131, and Sal 142. Fig. 9 shows the Salubra colors in order, from the most to the least difference between Near Easterners and Western Europeans. Participants from Near East compared with Western Europeans, prefer greens (Sal 040, Sal 052 and Sal 051), oranges (Sal 081), Red-Ochre (Sal 110), a light Sienna similar to pink (Sal 122), a light Brown (Sal 131), a light Shadow (Sal 142), Sienna (Sal 121), Vermilion-red (Sal 090) and an almost white color (Sal 001). Western Europeans prefer a dark gray (Sal 010) compared to Near Easterners. It seems that the presence of greens, pinks and slightly more saturated colors are on the roots of a bigger preference for bedrooms in participants from Near East compared with Western Europe.

If we analyze separately the most preferred individual Salubra colors in each culture, in the group of participants from Near East just three colors have a mean value over 4 ("neither like nor dislike"): Sal 052 ($MV = 5.00$), Sal 142 ($MV = 4.35$) and Sal 131 ($MV = 4.20$). In the group of Western Europeans just color Sal 010 ($MV = 4.23$) is rated slightly over 4 ("neither like nor dislike"). The pale yellowish

Table 4 Color preferences in bedrooms with significant differences between cultures. In order from the most to the least difference in each keyboard. Bold numbers indicate the most preferred bedrooms.

Bedroom	*Keyboard*	*Valeur de fond 1*	*Ton de Couleur 1*	*Ton de Couleur 2*	*Valeur de fond 2*	*Near East*	*Western Europe*	*Diff.*
129	*Mur I*	Sal 122	Sal 040	Sal 100	Sal 091	3.79	2.27	1.52
124	*Mur I*	Sal 122	Sal 141	Sal 050	Sal 091	4.00	2.68	1.32
121	*Mur I*	Sal 122	Sal 131	Sal 130	Sal 091	4.53	3.32	1.21
116	*Mur I*	Sal 112	Sal 040	Sal 100	Sal 122	3.94	2.77	1.17
105	*Mur I*	Sal 112	Sal 032	Sal 033	Sal 122	4.42	3.36	1.06
117	*Mur I*	Sal 112	Sal 100	Sal 121	Sal 122	**5.06**	**4.05**	1.01
106	*Mur I*	Sal 112	Sal 033	Sal 001	Sal 122	**4.63**	**3.64**	1.00
128	*Mur I*	Sal 122	Sal 041	Sal 040	Sal 091	3.88	2.91	0.97
210	*Paysage*	Sal 052	Sal 121	Sal 122	Sal 051	**4.88**	2.39	2.49
231	*Paysage*	Sal 051	Sal 090	Sal 102	Sal 053	4.50	2.08	2.42
214	*Paysage*	Sal 052	Sal 111	Sal 112	Sal 051	**4.78**	2.46	2.32
209	*Paysage*	Sal 052	Sal 120	Sal 121	Sal 051	4.03	2.23	1.80
212	*Paysage*	Sal 052	Sal 123	Sal 110	Sal 051	4.22	2.46	1.76
218	*Paysage*	Sal 052	Sal 090	Sal 102	Sal 051	4.28	2.54	1.74
222	*Paysage*	Sal 051	Sal 120	Sal 121	Sal 053	3.91	2.23	1.68
213	*Paysage*	Sal 052	Sal 110	Sal 111	Sal 051	4.03	2.38	1.65
216	*Paysage*	Sal 052	Sal 091	Sal 001	Sal 051	4.56	2.92	1.64
224	*Paysage*	Sal 051	Sal 122	Sal 123	Sal 053	3.91	2.31	1.60
233	*Paysage*	Sal 051	Sal 101	Sal 100	Sal 053	3.63	2.15	1.47
217	*Paysage*	Sal 052	Sal 001	Sal 090	Sal 051	3.97	2.62	1.35
229	*Paysage*	Sal 051	Sal 091	Sal 001	Sal 053	3.88	2.54	1.34
220	*Paysage*	Sal 052	Sal 101	Sal 100	Sal 051	3.53	2.23	1.30
219	*Paysage*	Sal 052	Sal 102	Sal 101	Sal 051	3.38	2.15	1.23
211	*Paysage*	Sal 052	Sal 122	Sal 123	Sal 051	3.97	3.08	0.89
215	*Paysage*	Sal 052	Sal 112	Sal 091	Sal 051	3.94	**3.15**	0.78
223	*Paysage*	Sal 051	Sal 121	Sal 122	Sal 053	3.56	**3.31**	0.25
241	*Bigarré I*	Sal 011	Sal 141	Sal 142	Sal 030	3.80	2.43	1.37
237	*Bigarré I*	Sal 011	Sal 122	Sal 110	Sal 030	3.55	2.29	1.26
242	*Bigarré I*	Sal 011	Sal 142	Sal 001	Sal 030	**4.18**	**2.95**	1.22
253	*Bigarré I*	Sal 030	Sal 140	Sal 141	Sal 130	**4.08**	**2.95**	1.12
248	*Bigarré I*	Sal 030	Sal 120	Sal 121	Sal 130	3.50	2.43	1.07
255	*Bigarré I*	Sal 030	Sal 142	Sal 001	Sal 130	4.29	3.29	1.00
252	*Bigarré I*	Sal 030	Sal 112	Sal 140	Sal 130	3.68	2.86	0.82
239	*Bigarré I*	Sal 011	Sal 112	Sal 140	Sal 030	3.65	2.86	0.79
238	*Bigarré I*	Sal 011	Sal 110	Sal 112	Sal 030	3.38	2.62	0.76
272	*Bigarré II*	Sal 110	Sal 010	Sal 091	Sal 120	3.69	1.79	1.90
283	*Bigarré II*	Sal 120	Sal 122	Sal 110	Sal 121	**4.10**	2.26	1.83
280	*Bigarré II*	Sal 120	Sal 090	Sal 120	Sal 121	2.92	1.21	1.71
277	*Bigarré II*	Sal 120	Sal 011	Sal 010	Sal 121	3.29	1.85	1.44
266	*Bigarré II*	Sal 110	Sal 140	Sal 141	Sal 120	3.56	2.15	1.41
270	*Bigarré II*	Sal 110	Sal 013	Sal 011	Sal 120	3.73	2.35	1.38
281	*Bigarré II*	Sal 120	Sal 120	Sal 121	Sal 121	**4.77**	**3.40**	1.37
284	*Bigarré II*	Sal 120	Sal 110	Sal 112	Sal 121	3.88	**2.55**	1.33
286	*Bigarré II*	Sal 120	Sal 140	Sal 141	Sal 121	3.39	2.25	1.14
304	*Bigarré III*	Sal 001	Sal 090	Sal 032	Sal 050	4.38	1.22	3.16
296	*Bigarré III*	Sal 020	Sal 090	Sal 102	Sal 001	**4.43**	**2.22**	2.21
298	*Bigarré III*	Sal 020	Sal 051	Sal 100	Sal 001	3.29	1.11	2.17
303	*Bigarré III*	Sal 001	Sal 123	Sal 090	Sal 050	3.71	1.67	2.05
310	*Bigarré III*	Sal 001	Sal 102	Sal 021	Sal 050	3.38	1.33	2.05
291	*Bigarré III*	Sal 020	Sal 040	Sal 111	Sal 001	3.29	1.44	1.84
312	*Bigarré III*	Sal 001	Sal 080	Sal 011	Sal 050	3.10	1.33	1.76
289	*Bigarré III*	Sal 020	Sal 122	Sal 123	Sal 001	**4.76**	**3.00**	1.76
301	*Bigarré III*	Sal 001	Sal 121	Sal 122	Sal 050	3.52	1.78	1.75
311	*Bigarré III*	Sal 001	Sal 021	Sal 080	Sal 050	3.29	1.56	1.73
306	*Bigarré III*	Sal 001	Sal 041	Sal 091	Sal 050	3.90	**2.22**	1.68
293	*Bigarré III*	Sal 020	Sal 112	Sal 091	Sal 001	3.52	1.89	1.63
309	*Bigarré III*	Sal 001	Sal 034	Sal 102	Sal 050	3.19	1.89	1.30



	Sal 052	*Sal 081*	*Sal 040*	*Sal 110*	*Sal 122*	*Sal 051*	*Sal 131*	*Sal 142*	*Sal 121*	*Sal 090*	*Sal 001*	*Sal 010*
Difference	4	1.75	1.5	1.18	1.13	1.08	0.7	0.67	0.66	0.53	0.24	-0.49

Fig. 9 Color preferences for individual Salubra colors with significant differences, from the most to the least difference, between Near Easterners and Western Europeans.

green Sal 052, is the only one that receives a rating in color preference equal to 5 ("Like slightly"), and just for the group of Near Easterners.

4. Discussion

We performed a cross-cultural study with students from architecture and interior design (250 Western Europe, 394 Near East), to assess color preference in interior architecture, after Le Corbusier's 1931 Salubra Keyboards. The descriptive analysis of the individuals' preferences for bedroom images, keyboards and individual colors, demonstrate that participants in general slightly dislike or are indifferent to Salubra color combinations displayed in the bedroom of the Swiss Pavilion (MV = 3.6) with just 23.7% of the bedrooms liked (MV $\geq$ 4). This indifference in color preference for the built environment is not an exception in literature (López-Tarruella et al., 2019) and some authors indicate that one reason could be that people often experience their physical environment at an unconscious level and are less aware of the influences of color (Van Der Voordt et al., 2017). Moreover, it is important to consider that the young designers may have a low attachment to a bedroom that was designed in 1930, and this global perception of an old-fashioned design might be undermining the average ratings. Nevertheless, despite the neutral to low ratings in general, our research findings demonstrate that color composition is able to shift the preference for an interior significantly up to 2.63 points on a Likert scale with 7 units, which is the difference between the most and the least preferred bedrooms.

Students prefer the bedroom images that contain the Cobalt Blues, Grays and Shadows. This result is coherent with previous research with blue being the most preferred hue in isolation (Camgöz et al., 2002; Mikellides, 2009; Wijk et al., 1999), and applied on buildings (Cubukcu and Kahraman, 2008). On the contrary, the least preferred bedrooms were those from the keyboards *Bigarré I, II and III*, and with the colors that correspond to the "main colors" in each pigment-hue family (yellowish-green, ultramarine-blue, vermilion-red, red-ochre, carmine-red, Veronese-green, Cobalt-blue, and orange). Our participants preferred lighter and less saturated versions of these Salubra "main colors". In literature about color preferences for isolated colors it is usual that brighter and more saturated colors are more preferred (Camgöz et al., 2002). Nevertheless, there is a common claim that color preference cannot be asked independently of an object (Holmes et al., 1984; Taft, 1997) and when colors are contextualized on building exteriors, previous results indicate a tendency for pale colors (Cubukcu and Kahraman, 2008) as we obtained for interior architecture. Curiously, the closest to white color in Salubra (Sal 001), receives a low rating despite previous research demonstrating that white is the most preferred color for building interiors (Bakker et al., 2015; Kaya and Epps, 2004; Kwallek et al., 1997; Van Der Voordt et al., 2017). Preference for white is a usual bias in architecture students that relies on a misunderstanding in considering that iconic modern architecture was achromatic (Serra Lluch, 2010). In the case of the Swiss Pavilion bedrooms, the extension of the white ceiling indicated by Le Corbusier seems to be enough and participants preferred lateral walls with hues different to white. Interestingly, in the study by Costa et al. (2018) to assess color preference of students in a university residence, white was found to be the most preferred color for the ceilings, while blue was considered to facilitate studying activity in interiors. Another interesting finding is that the presence of green colors in the bedroom images entailed a lower preference,

similarly to previous studies that demonstrated green to be disliked in interiors for Spanish respondents, and to entail a low sense of coziness (López-Tarruella et al., 2019). The most and least preferred color hues correlate with studies in other design related areas, demonstrating that more than 1 million Twitter users selected blues as the most preferred color, whereas greens the least preferred (Fortmann-Roe, 2013).

The results demonstrate that there are significant gender differences in preference for the bedroom images, keyboards and individual Salubra colors, but just for a few cases (5% of the bedrooms, N = 16) as reported in previous research (Ou et al., 2004; Sorokowski et al., 2014), and with females rating more positively than males as in Yildirim et al. (2011). Among the 12 color keyboards, males significantly preferred *Espace* compared to females, whereas females preferred *Mur I*. Despite the difference between genders, the two most preferred bedrooms for males and females were coincident in each keyboard. Regarding the preference for the 43 individual Salubra colors, we found significant differences between genders just for 20% (N = 9). Females preferred pale blues, pale green and pink, lighter and less saturated colors in general, while males opted for more saturated and darker colors in orange, Vermilion-red, and blues. It seems that our participants followed the stereotype that pink is a feminine color, a bias demonstrated in previous experiences with kids (Chiu et al., 2006) and adults (Hurlbert and Ling, 2007). Some authors sustain that this association between color preferences and gender may be mediated by sex differences in visual processing and evolutionary specialization (Alexander, 2003; Hurlbert and Ling, 2007), while others remark that it is a learnt stereotype, because children under 3 demonstrated no sex differences in preferences for pink over blue (Jadva et al., 2010), and males preferred pink compared to females in North America before World War II and there was a cultural shift in trends (Frassanito and Pettorini, 2008). Nevertheless, our findings are consistent with previous research that found a peak preference in males for the blue-green region and a minimum in the red-pink/purple region, while females preference peak in the red-pink region and purple/blue-green (Al-Rasheed, 2015). Regarding the darkness of the colors, previous studies have found gender differences for black in interior architecture (Manav, 2007), with males more in favor of darker colors compared to females (Fortmann-Roe, 2013). Curiously, the color Sal 040, which is the darkest and more saturated color in the Veronese-green pigment-hue family, a slightly bluish green, is an exception. Despite being darker than other green colors is more preferred by females than males. Following the ecological valence theory (Schloss and Palmer, 2009), the differences we obtained in color preference between the genders and cultures might be rooted in personal attachments to objects mediated in specific cultures.

The analysis demonstrates that there are significant differences between cultures in preference for the bedroom images, keyboards and individual Salubra colors, but just for a few cases (18.3% of the bedrooms, N = 57). This is coherent with previous research that found cultural differences in preference between arabic and English participants (Al-Rasheed, 2015), or between British and Chinese (Ou et al., 2004). Near Easterners give a higher rating in preference to the interior colors compared to Western Europeans, but the order of preference is almost coincident. Regarding the preference for the 43 individual Salubra colors, we found significant differences between cultures for 28% (N = 12, $P < 0.05$). It seems that the presence of greens, pinks and slightly more saturated colors are on the roots of a higher preference for bedrooms in participants from Near East compared with Western Europe. This finding is reasonably in line with previous ones that found the highest preference for hues in the blue-green region for English compared to Arabic and a preference drop for both cultures at green-yellow (Al-Rasheed, 2015). The bigger preference for green in Near Easterners fits with the findings of Manav (2007), which reported a strong tendency to choose green for residences. Nevertheless, the results demonstrate that color preference for interior architecture needs to consider not just the hue of the color, but also value and saturation. Colors with green hue have demonstrated to be undesired for interiors unless they have low saturation and high value. The importance of value and chroma has also been revealed in previous studies in residential buildings (Kaya and Crosby, 2006) and residential interiors (Ulusoy et al., 2020), with colors that have the same hue, but entail positive or negative connotations depending on their value and chroma. This is the case of orange (Munsell 5 YR) in the "entrance" of a residence, that was considered uncomfortable if vivid, but comfortable if soft (Ulusoy et al., 2020).

In the future, it would be necessary to investigate the influence of the three perceptual variables of color (hue, value and saturation) to evaluate the influence of each of them separately. Moreover, it would be worth working with Salubra colors translated into a standard color notation system to evaluate if the color combination criteria of the colors in each bedroom informs the preference. The color combination criteria refer to the similarity or contrasts among the perceptual variables of the colors of a composition, being evidence that individual colors shift their semantic associations when combined with others (Heller, 2004; Moretti et al., 2013). This study has discussed the like-dislike dimension, but in *Polychromie Architecturale*, Le Corbusier pointed out other subjective evaluations of the colors, such as calming-exciting, warm-fresh, melancholic, violent, etc. (Le Corbusier and Rüegg, 1997:99) None of these adjectives has ever been assessed in a scientific way after the keyboards and might be worth investigating in the future. On the other hand, it would be interesting to check if the neutral to low ratings obtained in the survey might be mediated by their application into an interior that is too distant to contemporary trends, so future research should consider more up to date interior designs.

The interest and validity of the contributions by Le Corbusier to the progress of architecture are beyond doubt, and Salubra 1931 colors are still considered a synonym of quality and aesthetic sensitivity. The actual presence of these colors in many "trendy" products is just an indication

of this interest that professionals still have in Le Corbusier's colors: paintings by © Kt color and © Keimfarben; switches by © Jung; carpets by © Anker; windows by © Heroal; Kitchens by © Leicht; tiles by © Cigaler and © Portobello, etc. The findings of the present research will help professionals in the understanding of the actual preferences for these colors in different cultures and genders, and help in their color combinations.

After an experiment to assess the color preferences for interior architecture, we can conclude that students from architecture and interior design in general, slightly dislike or are indifferent to Le Corbusier Salubra combinations applied in the interior of a bedroom of the Swiss Pavilion (1930—1931). Nevertheless, the color composition is able to shift the preference for an interior significantly up to 2.63 points on a Likert scale with 7 units. Participants have preferred pale and low saturated colors for interior architecture, the least preferred colors belonging to green and brown hues. Scarce significant gender differences have been found that follow a stereotyped tendency, with females preferring pinks, light blues and light greens, while males vivid oranges and Vermilions. Near Easterners are significantly more likely to green colors, while Western Europeans to dark greys. These data indicate that not only hue, but also value and saturation are important color features to inform preference for interior architecture and further research will be necessary in this sense.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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