Colour and Colorimetry
Multidisciplinary Contributions

Vol. XVII A

Edited by Andrea Siniscalco

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1. Color and Measurement/Instrumentation

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Evaluation of color alterations due to Ag-functionalized nanocrystalline cellulose on Whatman and Amalfi paper

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Abstract

Great part of the History of mankind is registered in form of work of art on paper support. Paper can be deteriorated due to physical, chemical, and biological agents. Among these latter, fungi represent the major paper biodeteriogens. Several methods have been used to control or stop fungal deterioration on paper-based materials, but their use can in turn induce color variations on paper. In this work a treatment for preservation and consolidation, based on nanocrystalline cellulose and silver nanoparticles (CNC/Ag) is analyzed. Two different types of paper (Whatman #1 and Amalfi) are treated by means of the suspension. Then spectral reflectance measurements are performed to infer CIELAB color coordinates of treated and not treated paper, in order to study the differences. It has been found that the use of CNC/Ag induces a pink coloration in the paper (reducing its hue), determines a darkening effect (reducing its lightness) and increases the saturation. Moreover, these alterations get more significant on time varying.

Keywords: color analysis, color alterations of paper, CIELAB color space, paper damages, antifungal methods.

Introduction

Deterioration of paper-based materials is an issue of utmost importance since archival and library resources represent a valuable work of art, in which great part of mankind history are registered. Papers, watermarks, inks, glues, leathers, and binding seams are elements that make paper heritage as precious as fragile. Paper like all other materials inevitably degrades over time due to endogenous factors like acidity, metal ions, lignin or paper degradation products, and exogenous factors like heat, humidity, radiation (light, UV), oxygen, pollutants or biodeteriogens (Kolar, 2005:6). Indeed, the organic composition of paper represents an ideal development substrate for microorganisms, especially fungi. Fungi can have deleterious effects on paper, due to combined factors. They act on main cell wall constituents, and can degrade cellulose, hemicellulose, and lignin, but they also can attack other organic materials as parchment, inks, and many types of glues and fillers (Sterflinger et al., 2012). Finally, many fungal species produce pigments that are released in the surrounding environment, contributing to foxing processes.

Treatments are necessary to preserve the integrity of paper, increasing its durability (Girardi et al., 2017; Isca et al., 2016) and ensure this legacy to future generation. In recent times, the use of a stable suspension of crystalline nanocellulose (CNC) was tested as starting material for paper preservation and consolidation due to its excellent properties such as high elastic modulus, optical transparency, low thermal expansion coefficient, biocompatibility, biodegradability and low toxicity. Moreover, the same CNC suspensions were also tested with the adding of silver nanoparticles (CNC/Ag), as it is well known that silver has broad-spectrum antimicrobial activity and high toxicity to different type of microorganisms (Bergamonti et al., 2020; Kamel, 2012; Nassar & Youssef, 2012).

However, the use of CNC and CNC/Ag suspensions could determine itself alterations of treated paper, among which, for example, color variations. The changes in the surface appearance of the paper samples have already been determined according to UNI EN 15886:2010 in a previous work of Bergamonti et al.,2020. Nevertheless, previous research has only covered one type of paper, namely Whatman #1, analyzing 7 regions of a few mm^2 in paper sample. Thus, the goal of the paper is to enlarge the analysis at two types of paper, namely Whatman #1 and Amalfi, analyzing 9 regions of 3x3 cm in each paper sample. They were subjected to artificial ageing process and then treated by means of CNC and CNC/Ag. Spectral reflectance measurements were performed, and then total reflectance values and L*a*b* color coordinates under D65 illuminant were obtained. All the results were compared to better understand the effects due to the use of CNC and CNC/Ag.

Method

As previously mentioned, the experiment was conducted on two different types of paper, Whatman #1 and Amalfi (hereinafter called WP and AP respectively). In this way it was possible to understand if the suspensions addition determines the same effects irrespective of the treated support, or not. WP is the most widely used filter paper for laboratory routine applications, it is made of 100% pure cotton linter and is characterized by high fiber elongation. AP is a fine paper produced since the Middle Ages in the city of Amalfi (Campania-Italy), it is made of cotton linter and hemp rags and is characterized by lower fiber elongation and by the presence of impurities (brown spots).

The experiment was divided in three different phases: 1) the preparation of the paper samples to analyze, 2) the spectral reflectance measurements, 3) the post-process of the measured data.

1. Preparation of the paper samples to analyze. For both WP and AP, 3 squared samples (side 3 cm) were cut and then subjected to accelerated ageing, to obtain targets whose conditions were representative of ancient papers. The artificial ageing was performed according to the ISO 5630-3 1996 standard. Specifically, they were put in a temperature and relative humidity chamber (DESPATCH LEA 1-69) at 80°C and 65% of relative humidity for 30 days. Then 1 of the 3 so-obtained samples was used as reference, whereas the other two were furtherly treated, the former by use of CNC and the latter by means of CNC/Ag. The treatments based on nanocrystalline cellulose and Ag nanoparticles, were synthesized according to Bergamonti et al. (2020). Cotton linters were hydrolysed by sulfuric acid (64 %) at 60°C for 40 minutes. The obtained product (CNC) was repeatedly washed, resuspended by centrifugation and purified in dialysis tube for one week up to neutral pH. 100 ml of suspension of silver nanoparticles (1000 ppm) were obtained by chemical reduction in water of a solution of $AgNO_3$ with $NaBH_4$ ($Ag/NaBH_4$ ratio 5/1) in presence of PVA 1% (ratio Ag/PVA 100/1 v/v) as stabilizing agent. CNC suspension (1% w/V) was mixed with the colloidal suspension of silver NPs (1000 ppm), with volume ratio 9/1 to obtain final suspensions 100 ppm (Ag).

   In summary, six different samples were obtained: 2 artificial aged samples in WP and AP (hereinafter referred to as WP_AA and AP_AA), 2 artificial aged samples in WP and AP treated with nanocrystalline cellulose (hereinafter referred to as WP_CNC and AP_CNC) and 2 artificial aged samples in WP and AP treated with Ag-functionalized nanocrystalline cellulose (hereinafter referred to as WP_CNC/Ag and AP_CNC/Ag).

2. Spectral reflectance measurements. Spectral reflectance measurements were performed by means of a Konica Minolta CM-2600d spectrophotometer on each sample by pointing the instrument towards 9 different points located on the squared cardboards according to the grid represented in Fig.1a. As it can be seen in the image, the first point P1 (represented in red) coincides with the center of the sample, the other 8 were placed in a median region (0,53 cm from the center) in shape of a cross (P2, P3, P4 and P5 represented in orange), and in a distal region (1.06 cm from

the center) in shape of a “X” (P6, P7, P8 and P9 represented in green). The suspensions were inoculated at the center of the targets corresponding to P1, so the analysis of the other points allowed to verify if the effects of the substance addition were homogeneous in the entire sample.

To align the instrument to the points of the measurements grid, masks (like stencils) of the same dimensions of the targets were prepared. They are schematized in Fig. 1b. They were obtained by cutting a black cardboard and ad hoc piercing it to get holes of the same diameter of the viewfinder of the instrument and located according to the described analysis grid. To perform the measurements each mask was overlapped in turn to each sample and the instrument was positioned such that its aperture hole corresponded to the holes of the cardboards. The spectrophotometer measures the reflectance of an area corresponding to its circular aperture hole (1 cm diameter). Consequently, given the dimensions of the samples and the distribution of the points, the 9 measurement areas (i.e., the holes in the masks) partly overlapped one each other. However, as it will be shown in the Results Section, the used method turned out to be effective in highlighting the differences among the 9 measured areas.

In previous trial experiments it was found that the selected papers were slightly transparent and transmitted part of the incident radiation. For this reason, during measurements samples were located on an opaque black almost not-reflective base. To guarantee the repeatability of the experiment, the NCS S9000N color sample was used as base. Moreover, it was observed that the color alterations due to the use of CNC/Ag were not stable on time varying. For this reason, the measurements were performed one month and half after the preparation of the samples and, in the case of the WP_CNC/Ag and AP_CNC/Ag, the measurements were repeated also immediately after the preparation of the samples, to give an idea about the color variations on time varying. During the month and half ranging from preparation to measurements, the samples were incubated in darkness at 25 ± 2°C with 40/50% of relative humidity.

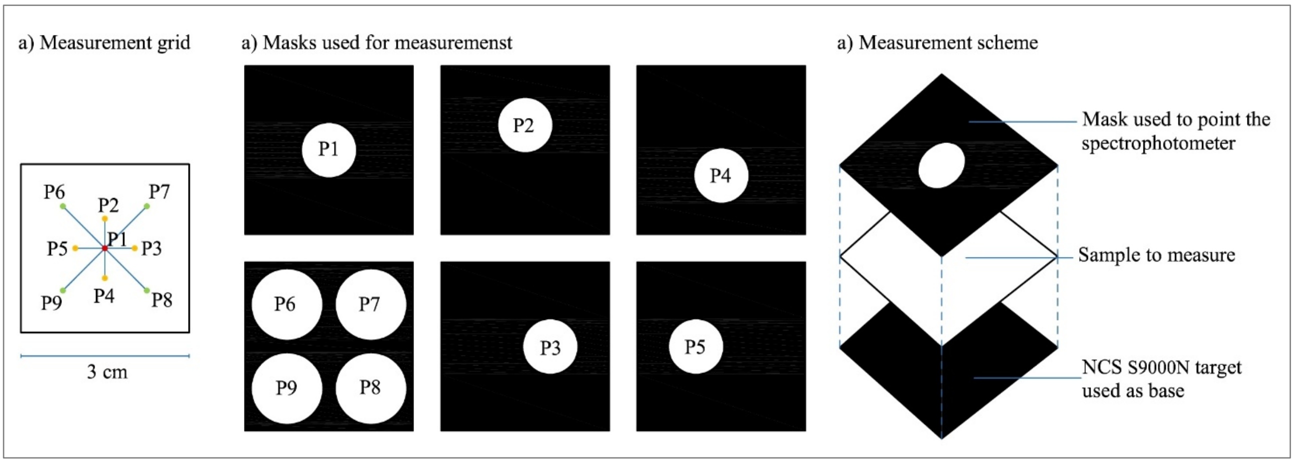

Fig. 1 – Scheme of the measurement grids and of the masks used to perform measurements

3. Post-process of the measured data. The following data were obtained from measurements: spectral reflectance curves for the 6 samples; total reflectance values under D65 illuminant (ρ_{D65}); CIE L*a*b* coordinates under D65 illuminant. All these data were compared to understand the effects of the use of CNC and CNC/Ag. Moreover, as regards the WP_CNC/Ag and AP_CNC/Ag the ΔE^*_{ab}, ΔL^*, Δh^*, and ΔC^* values were obtained for each point of the measurement grids comparing the results of the first measurements and those of the second ones, in order to quantify the color variations on time varying.

Results

Fig. 2 reports spectral reflectance curves of the 9 measured points for all the six analyzed samples. The total reflectance values under D65 are reported in Table 1.

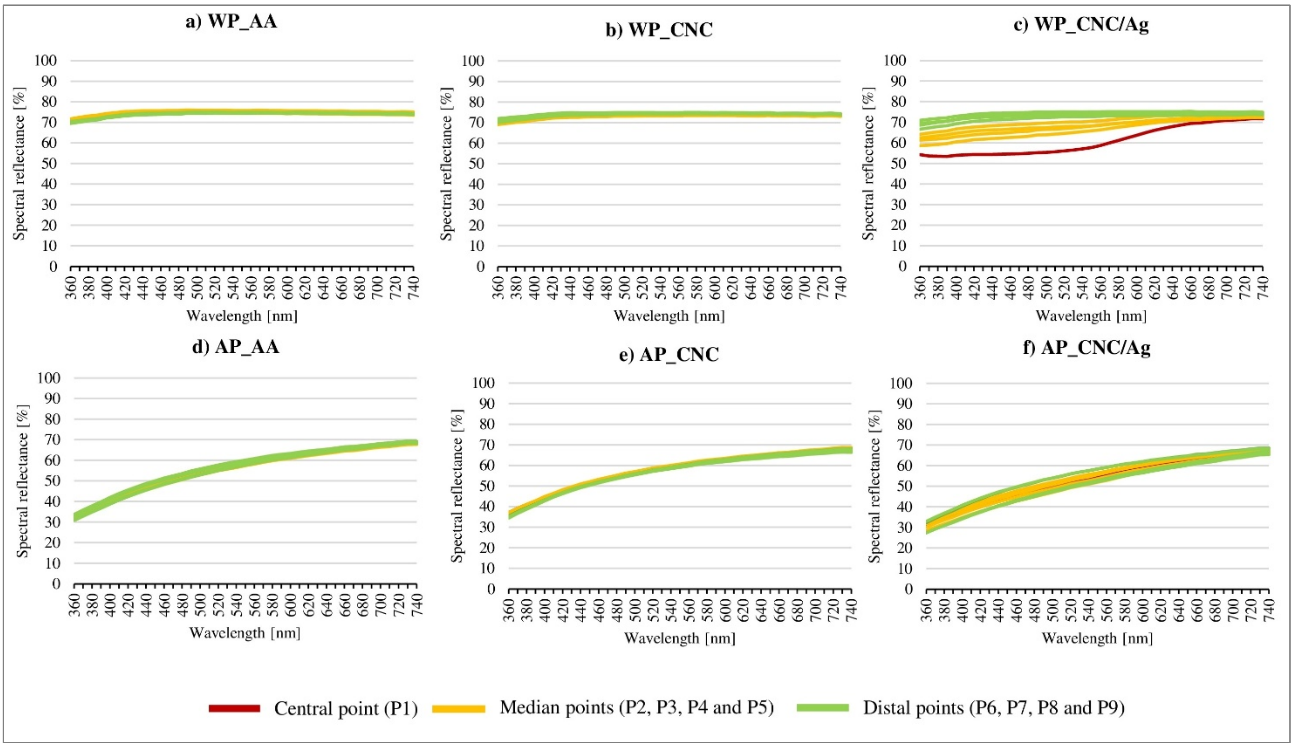

Fig. 2 – Spectral reflectance of measured points referred to each sample

The following observations can be inferred from the analysis of the spectral reflectance curves.

First of all, the two types of paper turn out to be very different. The comparison between the artificial aged and not treated samples (WP_AA and AP_AA represented in Figg. 2a and 2d respectively) shows that the WP_AA is characterized by spectral reflectance values almost constant from 420 nm on and equal to around 75.0%. Only in the range 360 nm - 420 nm the values are smaller and the minimum one is registered at 360 nm (around 70.0%). As it can be read in Table 1, this trend determines an average value of total reflectance equal to 74.9%. The standard deviation (SD) is low (0.5%), meaning that the average value is representative of the 9 points and consequently the paper is homogeneous and does not present high gradients of reflectance between a point and another. On the contrary, in the AP_AA the trend of the spectral reflectance curves is increasing and assumes values around 35.0% at 360 nm and around 70.0% corresponding to 740 nm. Consequently, the total reflectance values are lower than in the case of WP and equal to 58.3% on the average. Th SD is slightly higher (1.0%) than in the WP, meaning that the paper is less homogeneous.

As regards the effects due to the treatments, two main observations arise looking at Fig. 2: First, the use of CNC/Ag has more evident consequences than the use of CNC; second, the two types of paper do not react in the same way to the treatments.

In more detail, as regards the use of CNC, by comparing Figg. 1a and 1b it can be seen that the CNC addition determines for the WP a very little downwards shift of all the spectral reflectance curves. This shift is constant for all the wavelengths, so that the average total reflectance gets equal to 74.2%. On the contrary, on the AP the effect is almost the opposite, i.e., for the small wavelengths the spectral reflectance values increase (for example at 340 nm they are around

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35.0%). Consequently, the average total reflectance value is slightly higher than for the AP_AA and equal to 59.6%.

The addition of the Ag determines alterations of the spectral curves more evident, especially in the case of WP (see Fig. 1c). For this paper, the point P1, represented with red line on the graphs and corresponding to the central point of the measurements grid (where the substance was inoculated) is the most affected one. The spectral reflectance is significantly reduced (on the average 20.0%) in the range 340 nm- 520 nm and then start to increase again. The median points (represented in orange) are interested by a similar behavior, but the shifts of the curves are less significant. Therefore, reductions of the total reflectance values can be observed. They are diversified according to the considered points and the minimum value corresponds to P1 for which the total reflectance is equal to 59.0%. The average value referred to the 9 points is 69.9%, with SD equal to 5.1%, testifying that the ρ_{D65} values are not homogenous on the sample. On the contrary, as regards the AP, the shape of the reflectance spectra does not change a lot. They shift downwards and the reductions of the reflectance values are not equal for all the points. It is worth noticing that in this case the points for which the reductions are more significant are the distal ones and specifically P8 and P9 (with ρ_{D65} values equal to 52.7% and 52.1% respectively). So, the spread of the suspensions in the two papers has happened in a different way.

Table 1 – Total reflectance under D65 of measured points referred to each sample [%]

Point	Whatman #1 paper			Amalfi Paper		
	WP_AA	WP_CNC	WP_CNC/Ag	AP_AA	AP_CNC	AP_CNC/Ag
P1	75.6	73.8	59.0	59.0	59.7	54.2
P2	74.9	73.3	68.7	59.5	59.4	53.7
P3	74.4	74.3	66.2	57.1	59.6	56.3
P4	75.4	74.5	68.3	57.6	60.4	52.0
P5	75.8	73.9	70.8	57.7	60.0	55.5
P6	74.5	74.1	72.7	59.8	59.6	58.1
P7	74.4	74.5	75.1	58.9	59.6	58.2
P8	74.6	74.9	74.5	57.5	59.4	52.7
P9	74.9	74.8	73.8	57.4	58.8	52.1
Average value	74.9	74.2	69.9	58.3	59.6	54.8
Standard deviation	0.5	0.5	5.1	1.0	0.4	2.4

In Fig.3 the measured points are represented in the CIELAB color space for WP (Fig. 3a) and AP (Fig. 3b). The corresponding L*h*C* values are reported in Table 2 (for WP) and Table 3 (for AP).

Fig. 3a shows that points referred to WP/CNC are concentrated in the central part of the graph and mostly overlap those referred to the WP_AA sample. The mostly affected color coordinate is the hue that is generally reduced, indeed for the WP_AA it ranges from 109.4° to 151.3°, whereas for the WP_CNC from 101.3° to 123.7°. Even the L* is subjected to reductions. It ranges from 89.1 to 89.8 for WP_AA and from 88.6 to 89.3 for WP_CNC. On the contrary, the C* varies in the interval 0.2 to 0.6 for both samples. The results referred to the use of CNC/Ag are completely different. The distal points almost overlap those of the other two samples (WP_AA and WP/CNC), whereas the median ones and especially the central one are far from the others. For example, P1 is characterized by L*, h* and C* values equal to 81.3, 44.0° and 6.3 respectively. The median points are interested by reductions of L* and of h* and increments of C* as well compared to the WP_AA.

In the case of AP, the use of CNC determines a slight increment of lightness and hue compared to the AP_AA. Indeed, the L* values range from 80.2 to 81.7 for the AP_AA and from 81.2 to 82.1 for the AP_CNC, and the h* ones from 83.0° to 84.6° for the AP_AA and from 84.0° to 85.3° for the AP_CNC. The chroma is instead reduced, indeed it ranges from 9.6 to 10.7 for the AP_AA and from 7.9 to 8.8 for the AP_CNC. The addition of Ag determines a reduction of the lightness (lowest L* value equal to 77.3 observed for both P4 and P9) as already observed for the WP. Moreover, also in this case the hue is reduced and the chroma increased but the variations are not so evident like in the WP case. Specifically, the h* ranges from 77.2° to 82.9° and the C* ranges from 9.8 to 11.9.

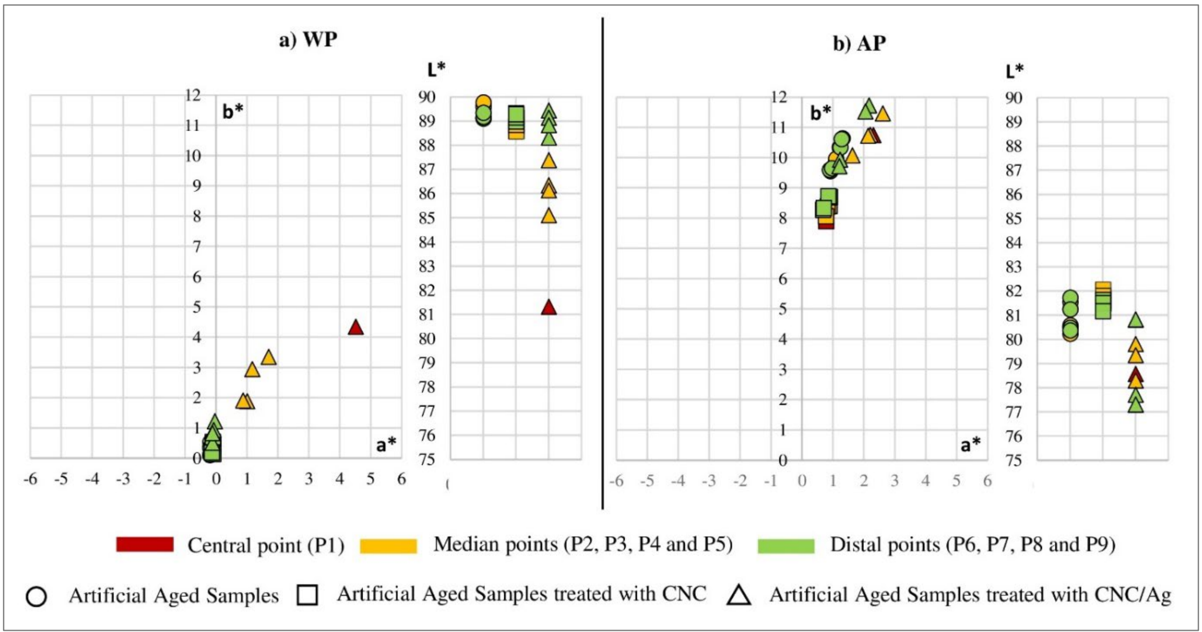

Fig. 3 – Representation of the measured points for each sample in the CIELAB color space

Table 2 – CIE L*h*C* values under D65 of measured points referred to each sample of Whatman #1 paper

	WP_AA			WP_CNC			WP_CNC/Ag		
Point	L*	h* [°]	C*	L*	h* [°]	C*	L*	h* [°]	C*
P1	89.7	136.7	0.2	88.8	102.8	0.5	81.3	44.0	6.3
P2	89.4	115.3	0.4	88.6	101.3	0.6	86.3	62.1	2.1
P3	89.1	151.2	0.2	89.1	105.9	0.4	85.1	63.2	3.8
P4	89.6	124.8	0.3	89.2	114.8	0.3	86.1	68.4	3.2
P5	89.8	138.4	0.2	88.9	104.0	0.5	87.4	65.5	2.1
P6	89.1	114.0	0.4	89.0	102.4	0.5	88.3	91.9	1.2
P7	89.1	109.4	0.6	89.2	123.0	0.2	89.4	103.0	0.5
P8	89.2	120.1	0.4	89.3	123.7	0.2	89.1	94.9	0.9
P9	89.4	119.1	0.4	89.3	125.0	0.2	88.8	98.1	0.8

Table 3 – CIE L*h*C* values under D65 of measured points referred to each sample of Amalfi paper

	AP_AA			AP_CNC			AP_CNC/Ag		
Point	L*	h* [°]	C*	L*	h* [°]	C*	L*	h* [°]	C*
P1	81.3	83.7	9.9	81.7	84.4	7.9	78.6	77.9	11.0
P2	81.6	84.5	9.6	81.5	84.0	8.5	78.3	78.4	11.0
P3	80.2	83.3	10.4	81.6	84.4	8.4	79.8	80.8	10.2
P4	80.5	83.7	10.0	82.1	84.5	8.1	77.3	77.2	11.8
P5	80.6	83.0	10.7	81.8	84.1	8.8	79.4	78.7	10.9
P6	81.7	84.6	9.6	81.6	84.1	8.7	80.8	82.9	10.0
P7	81.2	84.3	9.7	81.6	84.4	8.8	80.8	82.9	9.8

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P8	80.5	83.2	10.4	81.5	85.3	8.3	77.7	79.5	11.9
P9	80.4	83.1	10.7	81.2	85.2	8.4	77.3	79.9	11.7

Finally, in Table 4 color variations due to the effect of time on samples treated with CNC/Ag are described. First, it can be noticed that the two papers show a different behavior once again. The AP turns out to maintain almost constant the color characteristics on time varying. Indeed, the ΔE^*_{ab} values range from 0.3 to 0.8. On the contrary, for the WP, the differences are higher, and again they are particularly evident for P1. In this case the ΔE^*_{ab} is equal to 6.3. This color variation is due to a reduction of L* ($\Delta L^*=-3.3$) and h* ($\Delta h^*=-52.3°$) and to an increase of C* ($\Delta C^*=4.6$), meaning that the substance determines that the paper gets darker, more pinkish, and more saturated on time varying. A similar behavior (with less significant variations) can be observed for median points, whereas regarding the distal ones (P6, P7, P8 and P9) the ΔE^*_{ab} values are at most equal to 0.8.

Table 4 – Color variations due to the effect of time on samples treated with CNC/Ag

	Whatman #1 paper				Amalfi paper			
Point	ΔL^*	Δh^*	ΔC^*	ΔE^*_{ab}	ΔL^*	Δh^*	ΔC^*	ΔE^*_{ab}
P1	-3.3	-52.3	4.6	6.3	-0.7	-2.4	0.2	0.8
P2	-0.1	-33.8	1.1	1.4	-0.5	-2.8	0.2	0.8
P3	-2.7	-31.6	2.9	4.1	0.4	-0.5	-0.1	0.4
P4	-2.0	-22.4	1.7	2.8	-0.4	-2.1	0.2	0.6
P5	-1.0	-30.9	1.0	1.7	-0.3	-2.3	0.3	0.6
P6	0.2	-6.6	0.4	0.4	0.3	0.3	-0.2	0.3
P7	0.6	1.3	-0.1	0.6	0.5	-0.1	-0.4	0.6
P8	0.7	-1.7	-0.4	0.8	0.8	-0.1	-0.3	0.8
P9	-0.1	-0.5	-0.2	0.2	0.6	0.2	-0.1	0.6

Discussion and conclusions

The paper presented the results of spectral reflectance measurements aiming at investigating the color alterations induced by the use of nanocrystalline cellulose (CNC) and Ag-functionalized nanocrystalline cellulose (CNC/Ag) on two types of paper, Whatman #1 and Amalfi (WP and AP).

The following main results have been found:

-The two types of paper react in a different way to the same treatments.

-The use of CNC does not alter particularly the trend of the spectral reflectance curves in both papers. Specifically, in the case of WP there is a slight downwards shift of the curves, whereas for the AP an increase of the spectral reflectance values has been observed for small wavelengths. As a consequence, the average reflectance values vary from 74.9% (in the WP_AA) to 74.2% (in the WP_CNC) for the WP and from 58.3% (in the AP_AA) to 59.6% (in the AP_CNC) for the AP. As regards the color appearance, for the WP the use of CNC determines slight reductions of h* (for the WP_AA it ranges from 109.4° to 151.3°, whereas for the WP_CNC from 101.3° to 123.7°) and L* (it ranges from 89.1 to 89.8 for WP_AA and from 88.6 to 89.3 for WP_CNC) and does not affect the C* (values comprised between 0.2 and 0.6 for both samples). On the contrary, for the AP slight increments of lightness (L* values ranging from 80.2 to 81.7 for the AP_AA and from 81.2 to 82.1 for the AP_CNC) and hue (h* values ranging from 83.0° to 84.6° for the AP_AA and from 84.0° to 85.3° for the AP_CNC) were observed. The chroma is instead reduced (it ranges from 9.6 to 10.7 for the AP_AA and from 7.9 to 8.8 for the AP_CNC).

-The use of CNC/Ag significantly change the spectral reflectance curve especially for the WP and for P1. For this point, the spectral reflectance values decreased in the range 340 nm - 520 nm and then start to increase again. Consequently, the total reflectance assumes a value equal to 59.0%. As for the color appearance, the P1 gets darker, more pinkish, and more saturated. Similar behavior has been observed for median points as well. In the case of AP, the effect of the Ag addition is less evident. The spectral reflectance curves simply shift downwards but the trend is not particularly modified. Therefore, the average value of the reflectance (54.8%) is lower than the aged sample (58.3%). Also for this paper, the addition of Ag determines a reduction of the lightness and of the hue, whereas the effects on C* are negligible.

-The spread of the substances on the paper samples is not homogenous so determine different alterations for the different observed points.

-The color variations are not stable on time varying.

Despite the obtained results, further studies are needed to deepen the topic. For example, considering that it has been demonstrated that the two papers react in a different way, the experiments could be repeated on other types of paper, to extend the outcomes to a wider group of materials. Moreover, the effect of time on color variations should be furtherly studied. For example, the measurements could be repeated after a longer time, or after a further artificial ageing process. Another important issue is that, as demonstrated by the results, the spread of the suspensions on the paper is not homogeneous, so the color alterations are not equal in all the measured points. Other methods to inoculate the substances could be experimented and verified. Moreover, here only very small samples were analyzed, the treatments could be applied on entire pages to understand which is the final effect in a more realistic application.

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Simultaneous contrast in screen printed patterns

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Abstract
The paper investigates the visual color change that occurs on a sample screen-printed with printing paste of identical composition containing pigment CHT Colormatch 740 Schwarz in the mass of 30 g of pigment per 100 g of total printing paste mass. After applying the same printing paste on textile substrate coloured in black and magenta hues, a visual difference in color appearance occurred between the samples. While on a magenta background the print looks completely black, on a black background the visual appearance of the color is much lighter. Screen-printing was carried out for the purpose of patterning the materials for the designer collection of backpacks, and a similar effect was achieved when applying printing pastes in magenta hue. In addition to visual analysis, color objectification was performed on the samples based on spectrophotometric measurement and presentation of results according to the CIELAB evaluation system and through the values of color depth K/S. Microscopic imaging of the surface was performed to assess surface coverage and layer uniformity, and in the process of visual analysis, not only the impact of the substrate was assessed, but also of the surrounding colors (contours).
Keywords: simultaneous contrast, colour objectification, CIELAB, K/S.

Introduction

The perceived color of a surface depends not only on the spectral content of the light that reaches the eye but also on its context, background or surrounding colours; i.e. color appearance depends on spatial context (Ratnasingam and Anderson, 2017; Kanematsu and Koida, 2020). One of the oldest and most extensively studied forms of context dependence is a simultaneous contrast phenomenon. Simultaneous contrast is a psychophysical visual effect that is caused by a change in the background color; the effect that shows that the representation of one part of light depends not only on the light but also on the context in which the light is presented (Hajdek, M. *et. al.* 2018). According to (Soranzo, A., 2016), simultaneous color contrast is the condition whereby two surfaces with the same spectral composition are perceived to have a different colour when they are placed against different chromatic backgrounds (Fig. 1). According to (Hirschler *et. al.*, 2022), simultaneous contrast may be defined generically as a change in perceived colour due to its adjacent colour. Generally, simultaneous contrast is the induced enhancement of differences between a given color and surrounding colors; it is the effect of the surround on the color one perceives (Brewer, 1992). The term “simultaneous” was introduced by M. E. Chevreul to “distinguish this phenomenon to the ‘successive’ contrast, where two colours appear in succession upon the same retinal area”. The contrast has a great impact on color perception – it describes the influence of one color on the perception of colors in adjacent areas – the perceived color of the surfaces is “contrasted” by the color of the surround (Brewer, 1992). Contrast is the difference of luminance between the surfaces of different areas and/or elements on the surface ((Hajdek, M. *et. al.* 2018).); Shepherd, 1999; Ichihara, Kitagawa and Akutsu, 2007). When placing a brighter color as the background, the color appears darker; while when placing a darker color as the background, the color appears brighter (Hajdek, M. *et. al.* 2018). As the term “contrast” is also used in the literature to indicate the relative intensity of the stimulation, some authors prefer the term “induction” over contrast.

Apart from the psychophysical visual effect of achromatic simultaneous contrast which is also called achromatic induction, there is also chromatic induction which is based on the difference between the chromatic pairs of colors (Hajdek, M. *et. al.* 2018). When the squares and the backgrounds are achromatic, this phenomenon is named *Simultaneous Brightness (or Lightness)*

Contrast effect (Fig. 2). The definitions also suggest *simultaneous contrast* should be used only for chromatic effects (Brewer, 1992). Simultaneous color contrast is most studied phenomena in visual perception and that has interested scientists and philosophers since Aristotle's time (Soranzo, A., 2016; Hajdek, M. *et. al.* 2018). In the nineteenth century different explanations for simultaneous contrast have been given by Hering and Helmholtz. Hering (1920) supported an explanation based on retinal neuron interaction processes. To explain the contrast phenomenon the retinal-based interpretation focuses on the notion that the receptors that are stimulated by the background then send inhibition to the receptors that are stimulated by the surrounded area (Soranzo, A., 2016). According to this view, the simultaneous color contrast shown in Fig. 1 occurs because the receptors stimulated by the red background inhibit the red sensitive receptors stimulated by the orange square, leading to a yellowish appearance. Conversely, the receptors stimulated by the yellow background inhibit the yellow sensitive receptors stimulated by the orange square, leading to a reddish appearance. A similar explanation is provided for the contrast phenomenon seen in Fig. 2. The receptors stimulated by the light background send inhibition to the receptors stimulated by the patch that the background surrounds, causing perceptual darkening. On the other hand, the receptors stimulated by the dark background send little inhibition to nearby receptors, and therefore, there is no darkening effect. Two squares, one on a dark background and the other on a light one, appear to have different brightness despite being physically equi-luminant (Sinha *et al*., 2020).
Another, classically identified with Helmholtz, offers a cognitive account in terms of the most likely interpretation of the scene – he was in favor of an explanation based on higher-level processes, involving assumptions about the configuration as a whole (Bosten and Mollon, 2010; Soranzo, A., 2016). Figure 1 shows the central components of the squares that are physically identical in the centres of red and yellow surrounds. The appearance of the color is different, however. The two squares appear to aquire the opposite spectral component of their surrounds. The two inner squares in the left and right displays are physically identical, but appear different because the two surround colors influence the appearance of the squares. For this particular combination of target and surrounds, the difference in perceived color of the square is quite strong.

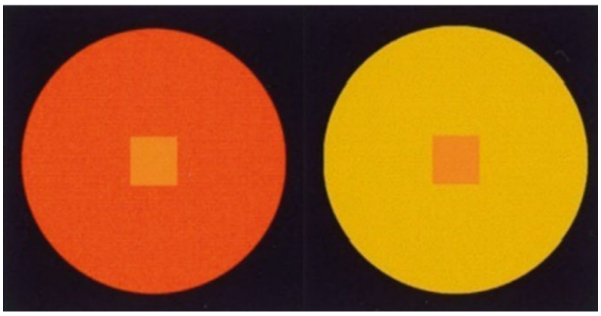


Fig. 1 – Simultaneous color contrast (Soranzo, A., 2016).

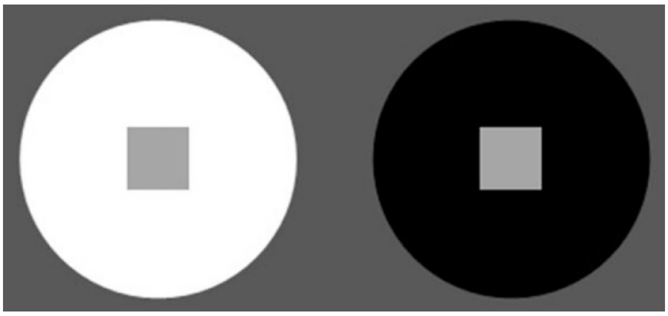


Fig. 2 – Simultaneous color contrast (Soranzo, A., 2016).

A similar explanation is provided for the contrast phenomenon seen in Fig. 2. The receptors stimulated by the light background send inhibition to the receptors stimulated by the patch that the background surrounds, causing perceptual darkening. On the other hand, the receptors stimulated by the dark background send little inhibition to nearby receptors, and therefore, there is no darkening effect (Soranzo, A., 2016).

1.1. M. E. Chevreul and J. itten - Simultaneous contrast

As mentioned before, Michel-Eugène Chevreul is the 'father' of simultaneous contrast research and made numerous controlled observations of the effect. He was a French chemist and professor of physical science. Fascinated by visual color phenomena, he spent years investigating the subject of optical colour mixing and is considered to be the first to explain the concept of simultaneous contrast for a wide audience. As director of dye laboratory of the Gobelin Workshop, he initially focused on finding the cause in dyeing process but because of lack of results, Chevreul turned his investigation to optic phenomena and properties of the eye (Luke, J., Chevreul, M. and Birren, F.,

1988). His devotion led to the finding that a combination of threads in a woven fabric results in a new color being produced in the retina of the eye. It meant that it is possible to reduce the number of dyes and still be able to produce a rich range of colors. In 1839, Chevreul published the Law of Simultaneous Contrast stating that “two adjacent colours, when seen by the eye, will appear as dissimilar as possible.” His work work was not as fundamental as that of Hermann von Helmholtz, who lived during the same period in Germany. Helmholtz focused on physiological optics, the issues that later formed the basis for color science, while Chevreul looked at color from the viewpoint of the user. His explanation was not at the level of what visual mechanisms lie behind the perception, but rather a systematic description of what the human perception of the colors is. Chevreul did not differentiate between what are now called 'additive' and 'subtractive' color mixtures, i.e. the different colors resulting from the mixture of beams of coloured lights versus the mixture of paints or inks. His theories on colour harmony are still those taught in art and design courses. In addition to giving general rules for achieving harmony, he reports on the attractiveness of specific groups of colours seen together (Luke, J., Chevreul, M. and Birren, F., 1988). Chevreul devoted his entire work to simultaneous contrast; however, systematic and practical exploration of colour contrasts (with exercises) was essential of J. Itten's course of instruction. According to Itten, there are seven kinds of colour contrasts, namely: contrast of hue, light-dark contrast, cold-warm contrast, complementary contrast, simultaneous contrast, contrast of saturation and contras of extension. He states that „the simultaneous contrast results from the fact that for any given colour the eye simultaneously requires complementary colour and generates it spontaneously if fit is not already present (Itten, J., 1970).“
This effect is shown on Fig. 4; „Each of six pure colour squares contains a small neutral gray square, matching the background colour in brilliance. 31-36 Each gray square seems to be tinged with the complementary of the background. The simultaneous effect becomes more intensem the longer the principal colour of a square is viewed. 37 Three small gray squares (Itten, J., 1970).“

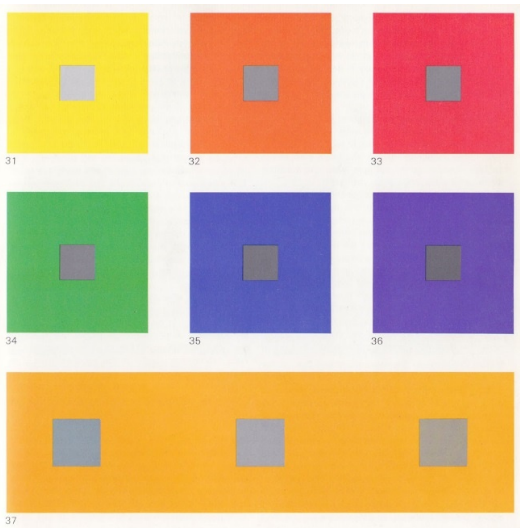


Fig. 4 – Simultaneous contrast by Johannes Itten (Itten, J., 1970)

Materials and Methods

In the methodological part of the work, the design of motifs and the patterning of textile material intended for the creation of author's backpacks were approached. A waterproof fabric with a raw material composition of 100% PES (polyester) was chosen, with a pronounced weaving structure on the face and impregnation on the reverse side. Figure 4 shows a microscopic picture of the structure of the undyed sample. The weaving structure is visible from the face, while the impregnation layer of 100% polyurethane is visible between the weave points.

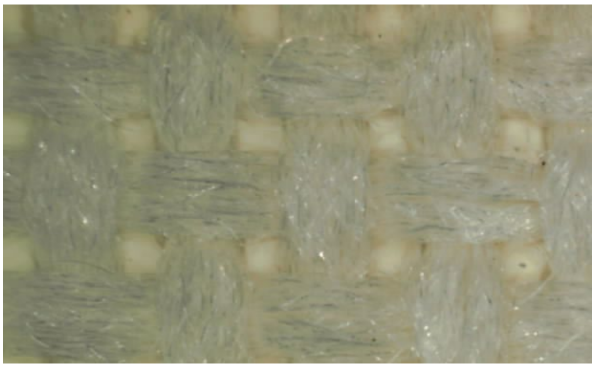


Fig. 4 – The microscopic image of the undyed textile material

The microscopic imaging was performed by DinoLite AM7013, with the following parameters: magnification: 50×/1.3 MP; unit: mm; horizontal FOV [accuracy]: 9.564 mm [+/− 0.192 mm]; one pixel increment (one keyboard arrow press): ~7.4 um).

In addition to the substrate shown in the picture, other substrates with the same raw material composition were chosen in magenta and black.

Manual screen printing was chosen as the realization technology. The printing was carried out with printing pastes intended for pigment printing, prepared with an industrially produced, ready-made base having a defined composition of thickener, binder, crosslinker and fixing agent ratio. Two types of such bases for pigment printing were used: a base for covering pigment printing with the addition of Titanium dioxide (TiO_2) - a white pigment that has the property of completely covering the color of the substrate; and a base for effective relief (so-called expansion) printing, which in its composition contains components based on vinylidene chloride ($C_2H_2Cl_2$), which in the fixing phase, under the influence of high temperature, produces gases causing swelling of the print, resulting in a special, swollen, relief effect. The trade names of the printing base are Printperfekt Blanc 450 containing Titanium dioxide for covering printing and Tubiscreen EX-TS for effective, relief printing. The pigments used were CHT Bezena Schwarz 740, Gold Gelb 110, Rosa 240, Rosa 241, Fucsia 250. Printing bases and pigments are both provided by the Swiss producer CHT Bezema.

Pigments were used to achieve the target coloration, and for each coloration a printing paste was prepared with both mentioned bases.

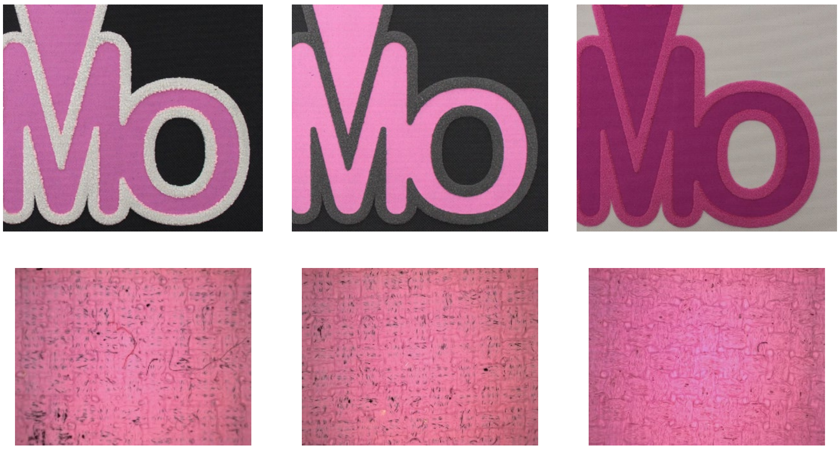
After the printing the coloristic analyses was performed, subjective and objective ones based on instrumental spectrophotometric measurement performed by remission spectrophotometer DataColor®850, with constant instrument aperture, standard light D65 and d/8° geometry. The results are shown in terms of color coordinates (a*/b*), main colour parameters (L*, C, h°) and color depth (K/S), calculated according to CIELAB system.

Results and Discussion

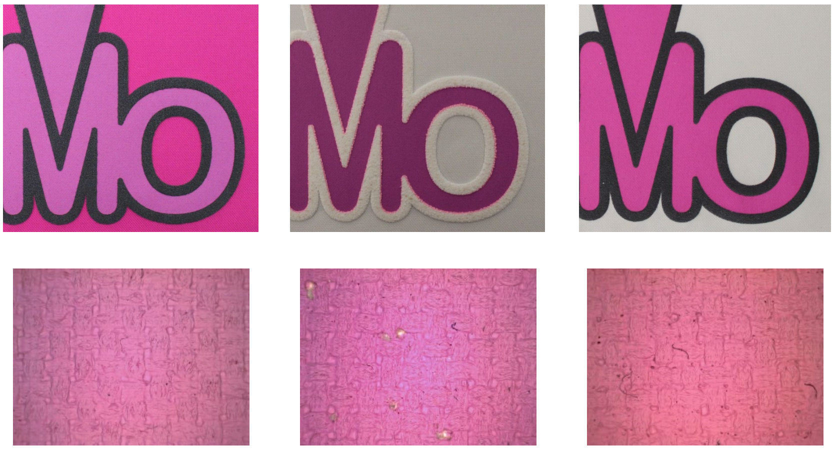
At the beginning of the discussion, it should be emphasized that all prints grouped under the names "Prints with black-gray printing paste" (Fig. 5) and "Prints with magenta printing paste" (Fig. 6), were printed with printing pastes of identical composition and concentration of the same pigment. CHT Bezena Schwarz 740 pigment was used for the samples grouped under the name "Prints with black-grey printing paste", and a mixture of CHT Bezema Rosa 240, Rosa 241 and Fucsia 250 pigments was used for the samples grouped under the name " Prints with magenta printing paste".

Sample 1B Sample 2B Sample 3B Sample 4B Sample 5B

Fig. 5 – Photographs of samples grouped as “Prints with **black-gray** printing paste”, and microscopic images of printed layers



Sample 1M Sample 2M Sample 3M



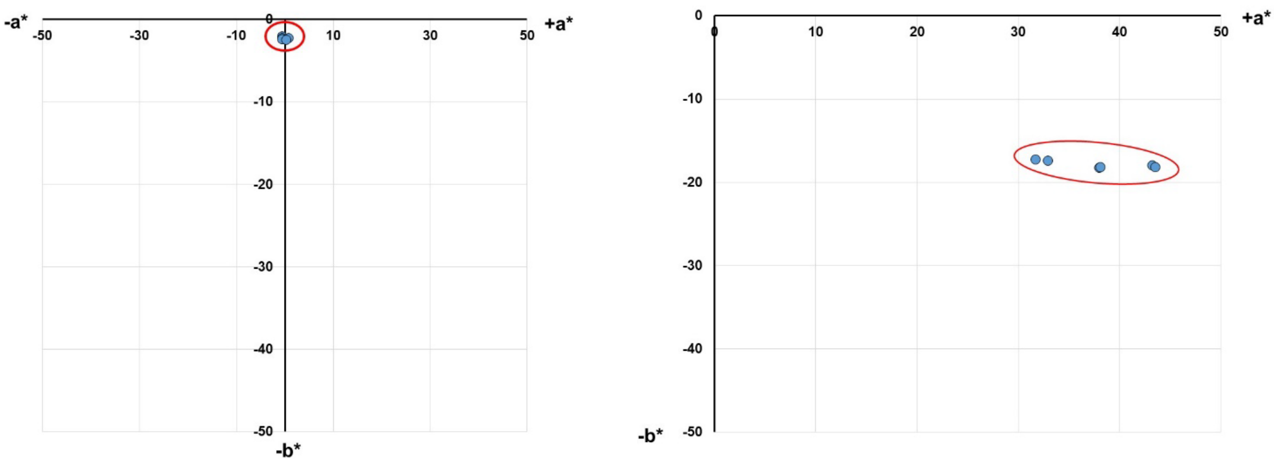
Sample 4M Sample 5M Sample 6M

Fig. 6 – Photographs of samples grouped as “Prints with **magenta** printing paste”, and microscopic images of printed layers

A visual comparison of the printed samples reveals a strong influence of the substrate as well as the color and structure of the contour of the motif, which lead to visible differences in the appearance of the color. With prints in black and gray color, there is a change in the perception of lightness, while with prints in magenta color, there is a change in the experience of all three visual color parameters – lightness, chroma and hue.

But, regardless the strong changes in the color appearance in the visual experience of the entire motif, microscopic images of the layer of pigment paste, applied by the printing process, confirm that all the samples were printed with the printing paste of an identical shade.

In order to confirm the objective equality of the color of the printing pastes used in both groups of samples, a spectrophotometric measurement of the color and a numerical evaluation of the coordinate and colouristic values of the prints were carried out. Figure 7 shows the placement of color in the a*/b* coordinate space. For the black color, it is confirmed that it is an identical coloring. In the case of the magenta color hue, slight shifts in the coordinate position of the color can be seen, indicating small differences in chroma, but it is still confirmed that it is a uniform coloring.



a) b)

Fig. 7 – Color placement in a*/b* color space; a) for the motif printed in black-gray; b) for motif printed in magenta color

Tables 1 and 2 show the objective values of the color parameters of the printed colors (lightness L*, Chroma C* and hue h°). For black, these values also confirm the uniformity of all three parameters, while in the case of magenta printing, slight differences in Chroma and lightness appear, while the hue value is practically identical. Such results, for both groups of samples, confirms the objective uniformity of the color, regardless of the visual appearance.

Tab. 1 – L, C, h, values for black prints

	L*	C*	h°
Sample 1B	33.25	2.07	256.06
Sample 2B	31.89	2.43	258.21
Sample 3B	34.82	2.38	288.15
Sample 4B	33.05	2.49	277.31
Sample 5B	32.20	2.31	257.52

Tab. 2 – L, C, h, values for magenta prints

	L*	C*	h°
Sample 1M	56.53	37.27	332.11
Sample 2M	55.91	36.12	331.48
Sample 3M	53.96	46.83	337.44
Sample 4M	57.19	42.11	334.38
Sample 5M	58.20	42.22	334.54
Sample 6M	53.31	47.16	337.34

The remission characteristics of the black and magenta prints (Fig. 8) also confirm the spectral uniformity of the coloring.

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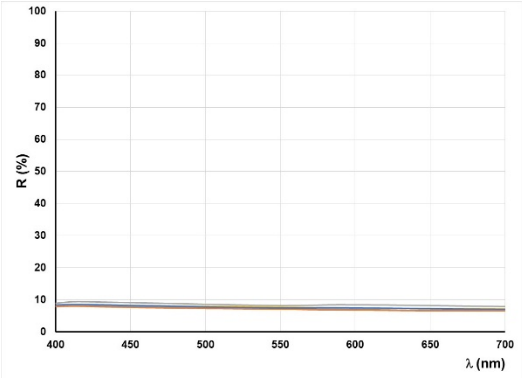
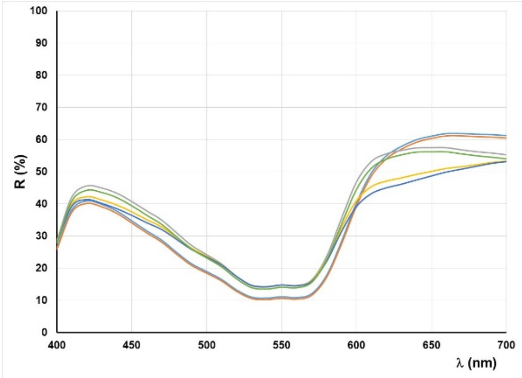


a)



b)

Fig. 8 – Remission characteristic (curves) of; a) the motif printed in black-gray; b) the motif printed in magenta color

Slight differences that appear in the objective color values of magenta prints can also result from irregularities in the polymer layer. Microscopic images (Figs. 5 and 6) show the appearance of cracks in the layer of printing paste, as well as the unevenness of the surface coverage in some samples. This certainly contributes to the appearance of slight differences, because such irregularities influence the change in the ratio of reflected and scattered light in the context of quantity.

In the further analysis, the color differences were calculated based on the objective values of the color parameters. The differences are calculated according to the CMC (l:c) equation, which is accepted by the ISO 105 standard for evaluating the color differences on textiles. The results are expressed as the value of the total colour difference (dE_{CMC}) and as the differences in individual color parameters (dL_{CMC}, dC_{CMC}, dh_{CMC}). As a standard, in the group with a black-gray motif, Sample 1B was chosen, and in the group with a magenta motif, the standard is Sample 4M. The results are presented in Tables 3 and 4.

Tab. 3 – colour differences for samples with black-grey motif

	CMC DL*/SL	CMC DC*/SC	CMC DH*/SH	CMC DE
Sample 2B	-0.79	0.47	0.11	0.93
Sample 3B	0.92	0.40	1.66	1.94
Sample 4B	-0.12	0.55	1.13	1.26
Sample 5B	-0.61	0.32	0.08	0.69

Tab. 4 – colour differences for samples with magenta motif

	CMC DL*/SL	CMC DC*/SC	CMC DH*/SH	CMC DE
Sample 1M	-0.28	-2.04	-0.92	2.26
Sample 2M	-0.55	-2.53	-1.16	2.84
Sample 3M	-1.39	1.99	1.39	2.80
Sample 5M	0.44	0.05	0.07	0.44
Sample 6M	-1.66	2.13	1.35	3.02

The color differences also confirm what was stated in the previous analysis. For samples with a black-gray motif, the differences in the color hue (dh_{CMC}) are slightly outside the allowed tolerance limit, however, the values of the total color difference (dE_{CMC}) meet the allowed range.

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For the magenta motif, due to the differences in chroma, the values of the total color difference (dE_{CMC}) are slightly outside the tolerance limits. The results obtained in this way certainly indicate the importance of the influence of the pigment layer, its structure, uniformity and coverage. They can in no way be attributed to the actual difference in the coloring of the printing paste.

Conclusion

The optical phenomenon of simultaneous contrast is the subject of scientific research and artistic interest of generations of scientists and artists, and a significant number of scientific papers and books have been written about its causes and phenomena. The analysis carried out in this paper, and similar analyses, are a contribution to the understanding of how important it is to be aware of the level to which color can influence each other when they are combined in the relationships of background, framing and surface coloring. The results obtained by objective analysis confirm the strong appearance of simultaneous contrast in printed motifs, which occurs due to the strong interaction of the color of the substrate and the color of the contour around the motif itself.

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Effects of tinted lenses on chromatic sensitivity: changes in colour vision assessed with the CAD test, a preliminary study

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Abstract
The aim of this study was to assess the extreme effects of tinted lenses on colour vision by examining changes in chromatic sensitivity when viewing visual displays through a slightly tinted ('blue-blocking') filter and through a heavily tinted, 'orange' coloured filter. The CAD test was used to measure both red / green (RG) and yellow / blue (YB) chromatic sensitivity in ten subjects when viewing visual displays through each of the two filters. The measured RG and YB colour thresholds were then compared with similar measurements made without coloured filters in front of the eye. The blue-blocking filter absorbs only a small amount of short-wavelength light whilst the 'orange' filter attenuates preferentially more short wavelength and some middle-wavelength light. The results show that the blue-blocking filter does not affect significantly either RG or YB colour vision. The orange filter, on the other hand, causes large changes in colour discrimination. The results were analysed statistically by comparing results obtained with the coloured filters with those measured without any filters in front of the eye. More experimental work is now needed to establish how much short wavelength light can be removed without affecting significantly the subject's colour discrimination performance.

Keywords: anomalies of colour vision, filtering lenses.

Introduction

Colour vision is important since colour signals can be used to code information that improves our visual performance. The ability to discriminate different colours has many advantages in daily and professional life. Furthermore, it is mandatory to confirm compliance with safety standards in visually-demanding working environments where good colour perception is required (aviation, maritime transport, fire and rescue services, etc) (Barbur and Rodriguez-Carmona 2017).
People use lenses during their daily activities, because they need a correction for their refractive conditions or because they want to reduce the amount of light reaching the retina and also to minimise glare. Since the use of various types of ophthalmic lenses that are often spectrally selective is widespread, it is of interest to understand how the use of such lenses can affect colour vision. In particular, we would like to predict accurately how the subject's colour discrimination abilities are affected by the use of coloured lenses and to understand the possible repercussions the use of coloured lenses may have in normal daily life and in working environments. The immediate objective of this work is to evaluate how colour discrimination on visual displays varies when using coloured lenses in front of the eye. We report preliminary results which measure red/green (RG) and yellow/blue (YB) colour thresholds when viewing visual displays through coloured filters.

Tinted lens characteristics

Tinted lenses nowadays could be realised using two different methods. The traditional method uses the absorption properties of pigments, but in recent years it is common to use bespoke interference filters with selective absorption bands. Filters based on thin, multi-layer coatings can be designed to control accurately the amount of short-wavelength light absorbed by the lens. These two methods of producing coloured filters affect both the amount and the spectral composition of the transmitted light. Recently blue blocking lenses based on thin-layer coatings have been produced and made available commercially by lens manufacturers, claiming good protection from blue light (Comparetto and Farini, 2019). In our experiment we use two different lenses, one that relies on light absorption by spectrally-selective pigments, the other one a blue blocker lens produced multilayer thin film interference (Fig.1). Transmittance measurements were made using a Perkin Elmer 1050 spectrophotometer.

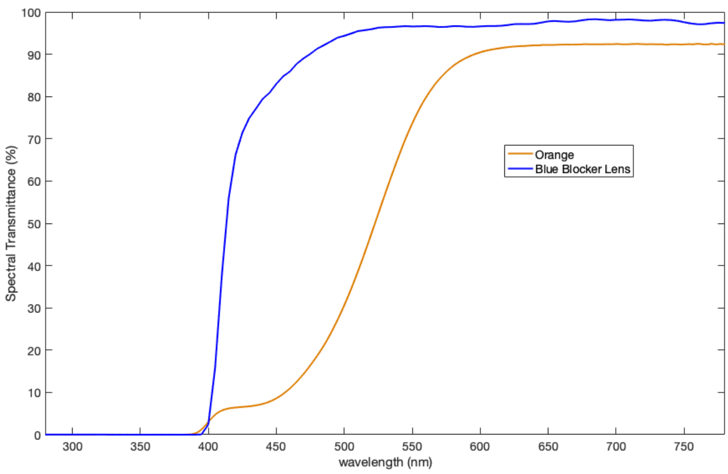

Fig. 1 – Spectral transmittance of the two lenses used in the experiment. The blue line is the blue blocker lens (Essilor Crizal Stylis, n=1.67), the orange line is an orange lens.

Subjects

Ten subjects (six men and four women), who ranged in age from 19 to 26 (mean age=22.1±2.4), participating in the study. We prefer to limit the age interval for our subjects because we want to study only the effect of tinted lenses, avoiding well-known effects on colour vision related to age (Barbur and Rodriguez-Carmona 2016). The subjects had binocular visual acuity better than one minute of arc (i.e. equivalent to 20/20 on the Snellen chart) and needed no refractive corrections to see clearly the test stimuli on the visual display.

Colour test

We use the Colour Assessment and Diagnosis (CAD) test in our experiment. The CAD test isolates the use of coloured signals and measures colour detection thresholds. Studies on camouflage showed that the use of dynamic luminance contrast noise masks the detection of luminance contrast signals without affecting significantly either RG or YB chromatic sensitivity (Barbur 2004). The test involves the use of a calibrated monitor, keyboard and a computer on which CAD software is installed. The test generates coloured stimuli on a visual display within a background of dynamic luminance contrast noise. The stimuli move along each diagonal direction, and the colours are selected to ensure automatic classification of the class of deficiency involved, as well as adequate estimates of both RG and YB colour thresholds (Fig.2A).
The subject's task is to indicate the direction of movement of the colour-defined stimulus using one of the four, raised, corner buttons on the numeric keypad. The test requires the subject's age which is an important parameter since the results are compared against the expected normal age limits. When the full test is carried out the results show the subject's RG and YB thresholds in CAD units. A graph is also displayed to indicate the measured RG and YB thresholds superimposed on the normal, age-matched chromatic threshold ellipse. The latter is plotted in the CIE *(x,y)*-1931 chromaticity diagram, together with the expected upper and lower threshold limits for the subject's age (Fig.2B).

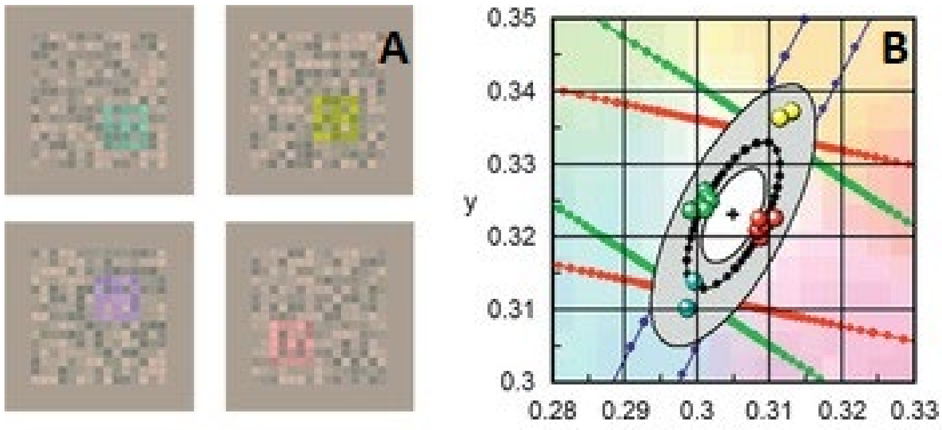

Fig. 2 – A) RG and YB stimuli employed in the CAD test. B) The statistical limits for the standard normal (SN) CAD observer are plotted in the CIE (x,y) 1931 chromaticity chart.

Results

The thresholds for the RG (Fig.3) and the YB (Fig.4) channels show that the orange lens causes a large loss of colour vision, while the blue blocker lens does not affect significantly either RG or YB colour thresholds.

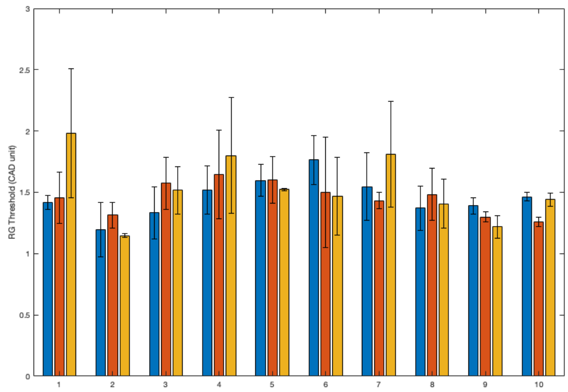

Fig. 3 – mean RG thresholds measured in the ten study participants for each of the three viewing conditions: direct viewing without any lens in front of the eye (blue bars), with the blue-blocker lens (red bars) and with the orange lens (orange bars). The vertical lines indicate the computed inter-subject variability (±σ)

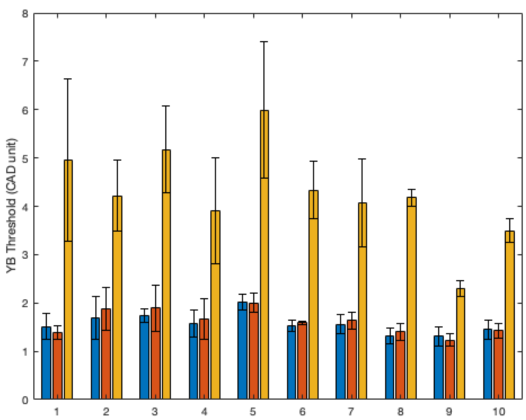

Fig. 4 – mean YB thresholds measured in the ten study participants for each of the three viewing conditions: direct viewing without any lens in front of the eye (blue bars), with the blue-blocker lens (red bars) and with the orange lens (orange bars). The vertical lines indicate the computed inter-subject variability (±σ)

In addition, we carried out a one-way ANOVA to compare the effect of type of lens on RG and YB threshold. This test revealed that there was a statistically significant difference in YB threshold between at least two groups ($F(2,27)=[65.24]$, $p<10^{-5}$). Tukey's HSD test for multiple comparisons revealed significant differences in YB thresholds when comparing the no lens and orange lens conditions ($p<10^{-5}$, 95% C.I.=[-2.6967,-2.0265]) and the blue-blocker lens and the orange lens ($p<10^{-5}$, 95% C.I.=[-2.6503,-1.9802]). The box plot for YB threshold is shown in Fig.5. There was no statistically significant difference between no lens and blue-blocker lens conditions ($p=0.98$). Regarding RG threshold, the one-way ANOVA revealed no statistically significant differences between the three conditions.

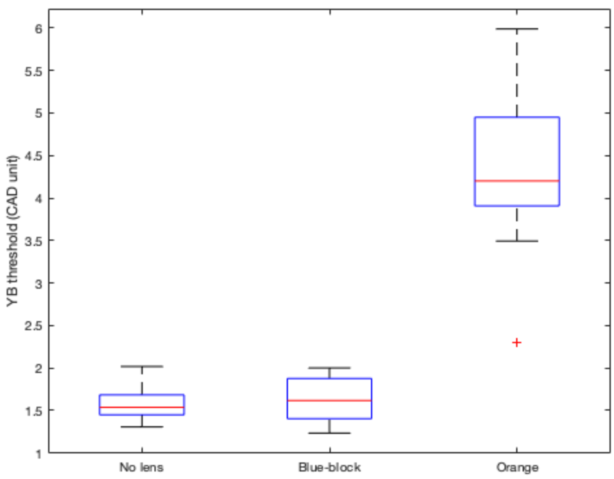

Fig. 5 –Box plot for YB threshold. The red line represents the median, the whiskers are the maximum and minimum value, the boxes are the 25 and 75 percentiles: the plot shows the large difference between the orange lens and the other two conditions.

Comparison of results plotted in fig.6 and fig.7 confirms that the orange lens strongly affects colour discrimination, whilst the effect of the blue-blocker lens is negligible.

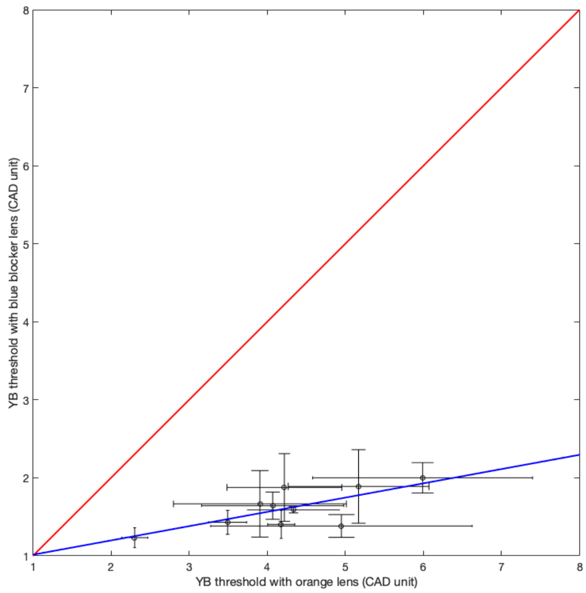

Fig. 6 –Relationship between YB threshold with orange lens (x axis) and with blue blocker lens (y axis). The error bars are the standard deviations. The blue line is the regression line ($y=0.18\,x+0.83$), the red line is the $y=x$ line. Pearson's $r = 0.72$.

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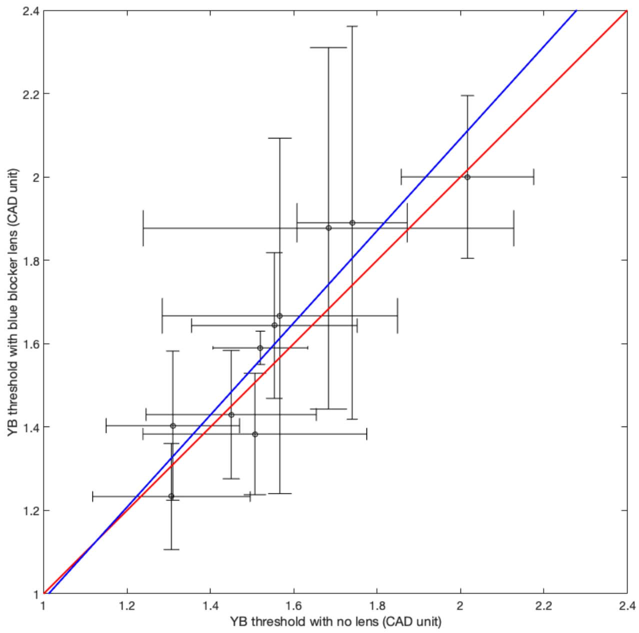

Fig. 7 –Relationship between YB threshold with no lens (x axis) and with blue blocker lens (y axis). The error bars are the standard deviations. The blue line is the regression line (y=1.10x-0.11), the red line is the y=x line. Pearson's *r*=0.92.

Conclusions

The findings reported here show that although commercial blue-blocking lenses have a negligible effect on colour discrimination on visual displays, coloured lenses that absorb a greater amount of short wavelength light can cause large loss of chromatic sensitivity with the YB channel being most affected. This preliminary study demonstrates that the CAD test could be used to assess objectively the maximum amount of short-wavelength light one can absorb with blue-blocking spectacle lenses without affecting significantly either RG or YB chromatic sensitivity.

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2. Color and Digital

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Color consistency in BIM systems and in the visualization of the project in Real Time - An overview of possible solutions

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Abstract

In today's panorama of tools available to the professional in architectural design field, the BIM methodology has recently spread more and more widely than in the past. This is also due to an increasingly stringent regulatory imposition in public procurement, especially concerning the estimated amount of the works.

Furthermore, in the 2000s the visualization of the project was mainly linked to photorealistic static renderings or popular films obtained from sequences of static images. Nowadays, the computing power of the available hardware and the evolution of the raytrace rendering engines have led to an increasingly frequent use of virtual reality and augmented reality, which therefore become renewed tools available to the designer to visualize and make the project better understood by the client and other professional actors involved in the design.

In both cases, once the color of a finish has been acquired through correctly calibrated devices and standardized procedures, the problem of its correct representation arises here. The theme appears complex and needs to be explored carefully. This text is therefore intended to be an overview of the currently available solutions, thus analyzing how the currently available applications address the issue of color consistency in the context of BIM and virtual reality.

Keywords: colormanagement, virtualreality, BIM.

Introduction

The BIM software on the market, which in recent times has been adopted more and more frequently by designers, has tools that facilitate the collection and sharing of project information and allow to build a virtual prototype of the building or the space to design. This model must be accompanied by detailed information relating to all construction elements. However, it cannot have a too high level of detail in terms of number of triangles and polygons used, since this would negatively affect the weight of the file in terms of bytes. Furthermore, the BIM methodology does not require the search for great graphic detail, as its focus is on other areas. Nevertheless, all BIM software are equipped with a module for visualizing the project. The images produced by this module can never be of a professional type, since the functions present are intuitive but minimal and simplified, and in addition, the model, for the reasons explained above, cannot have a solid graphic detail, especially on the furnishing elements. The BIM model's detail is appropiate only for general external architectural visualization.

At the same time, Virtual Reality and Augmented Reality applications are now having a great diffusion in indoor architectural visualization. Through these, photorealism in Real-Time has made significant progress, thanks to the evolution of rendering engines, AR / MR techniques (Alhakamy and Tuceryan, 2020) and the hardware capacity of modern video cards (Thoman *et al.*, 2022). In addition, some studies have shown that, especially in daylight simulations, the perception of space by the end user was particularly accurate (Chamilothori, Wienold and Andersen, 2019). Also in artificial lighting scenarios, the theme of visualization of the BIM model in VR visualization techniques has been studied, and good results have been obtained (Natephra *et al.*, 2017). For these reasons, the presentation of the project to the customer is experiencing a natural integration and evolution of static rendering towards these new visualization techniques.

Therefore, the need to find a way to present the BIM model through these new ways arises, improving the quality of the model without affecting the weight in bytes of the native file. As this is a continuous and rapid evolution field, the possible solutions are numerous and often different in the approach. Some already proposed in the past involve using multiple software applications (Wong *et al.*, 2019). Let us see here which tools can be used and if in these the theme of color fidelity is taken into account or not.

Preliminary Procedures

Regardless of the Real-Time solution that the designer chooses to use, the constancy of the color that he will want to verify cannot ignore two factors: a correct acquisition of the finish of the material sample and a faithful reproduction of the designed lighting scenario.

Most of the time, textures to use in CAD systems must have a standard sRGB color profile. As far as possible, the designer should avoid using textures downloaded from the internet, as it is rarely known: a) how they were acquired; b) if a standard procedure was followed; c) if the conversion of the relative color profile of the device to the absolute sRGB profile has been done and correctly. The designer should therefore opt for a live acquisition.

The possible procedures are two, one photographic and one via scanner. In both cases, the devices must be calibrated and have a relative color profile, periodically updated in the case of the scanner (Guarini, 2020) and obtained at the time of shooting in the case of the camera (Guarini and Rossi, 2021). The procedure, as well as the environmental conditions, must be standard and reproducible. Taking this last point into account, scanner acquisition is perhaps preferable in the case of thin material samples. The final image of the acquired texture must then be converted, using a dedicated program equipped with a CSM Manager, into the absolute sRGB color space. If the texture has to be repeated several times on a surface, it will then be refined in a photo editing program to be used as seamless.

The lighting conditions to carry out design simulations where it is possible to evaluate the color rendering of materials are basically two: natural light and artificial light.

The first is easier to manage, as each real-time simulation software has simplified commands that reproduce daytime or nighttime lighting. The parameters to set up are not numerous and essentially concern the simulation's date and time, the project's position and orientation, and the atmospheric conditions of the simulation. The designer must always take care not to modify the preset physical parameters, such as the sun's intensity and the solar disk's size, to avoid incorrect simulations in terms of the quantity of light and the visualization of shadows.

The artificial light condition requires more attention, as the designer should use the accurate photometric data of the luminaires he wants to use in the environment. The manufacturers of the appliances can supply these. The survey and acquisition techniques are constantly evolving. However, at present, the most widespread methodology consists in entering the data relating to the light intensity through photometric files (Siniscalco and Guarini, 2018) downloaded from the manufacturers' websites and the data relating to the color temperature of the sources by entering them manually from the technical data sheets of the device. Almost all real-time viewing software supports the insertion and the use of these files and these color temperatures. It is also necessary to verify that the software has available options or tools that allow using the real intensity distribution given by the file, without this being occluded or modified by the 3D geometry of the device itself.

PBR Materials

Almost all the proposed solutions we will list later and which deal with the Real-Time visualization of the projects use PBR materials (McDermott, 2018). Revit has recently introduced this type of material, even if they are still hidden and not easily accessible by the user. When assigning materials in Revit, it is preferable to use these directly to facilitate compatibility and reduce the work in Real-time Rendering applications. If on the sample present in the library there is an exclamation point on a yellow triangle, the Revit material is not a PBR material (Fig. 1). If you want to create a PBR material from scratch, the "Asset Browser> Appearance Library> Base Materials" library must be installed, where you can find five base PBR materials to start from (Fig. 2).

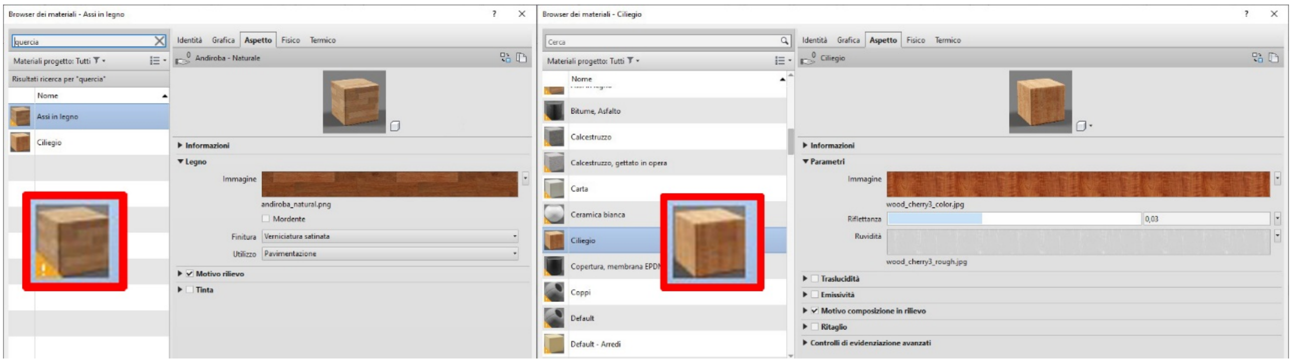

Fig. 1 - non PBR and PBR Materials in Revit

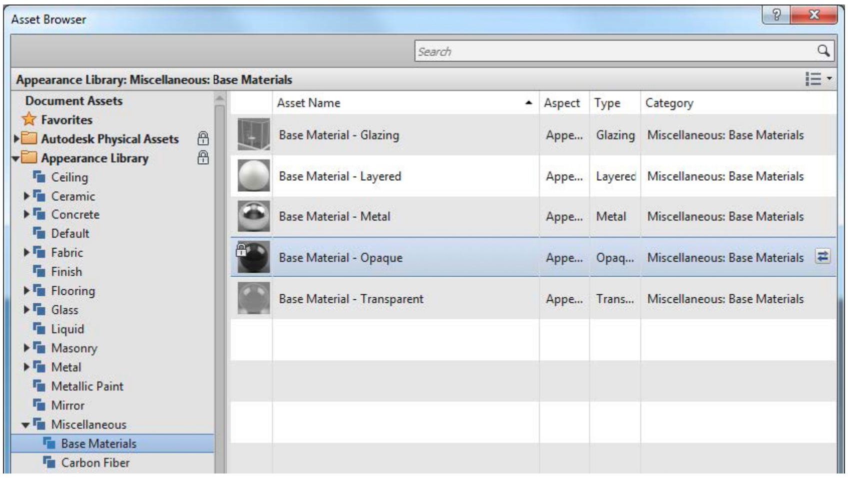

Fig. 2 - Base PBR Materials in Revit

These PBR materials are based on physical parameters, which can be set through values and preferably through specific texture images. These parameters in which to insert the maps are always the same, regardless of the software used. Once the designer has obtained the maps in question, he must connect them to the respective map channels of the application he wants to use. Among the most important, we mention the "Albedo" relating to the diffuse reflection of light, the "Roughness" relating to the surface imperfections of the surface and the "Height Map" relating to the bump.

Here the problem arises regarding how to obtain the textures related to these properties. Several sites offer pre-prepared textures for the various channels. However, as already explained, these should be avoided for a whole series of problems regarding the fidelity of the acquisition of the base color, which is why it would be advisable to use a texture acquired with known and standard procedures. Once obtained this, free software allows obtaining all the others textures from the first image. An example of this software is Materialize (*Bounding Box Software - Materialize*, no date).

However, we outline that the procedure for obtaining images with sRGB profile to be used in the Albedo property tries to return the color as faithfully as possible. Instead, this free software that renders the other maps helps to give a more realistic appearance to the final finish by acting on the gloss of the material and its roughness, but they work empirically and reproducing the type of finish is due to the designer's ability.

Available solutions

After following the preliminary procedures and using PBR materials where possible, a dedicated application or plugin is still required to easily view the project in real-time. The BIM software has a module for viewing the rendering of the project, which, however, has a limited set of tools and does not solve the problems related to the interaction of the photometric solid within the lighting fixture. Furthermore, they do not have a module for real-time viewing. Some integrated and cloud-based solutions were implemented but were subsequently discontinued, such as "Revit Live"(*Revit Live | Autodesk*, 2020).

However, several solutions are currently available, given the ever-increasing diffusion of Realtime Visualization and Augmented Reality. Among these, even professional rendering engines with years of experience in the visualization sector have developed additional real-time applications to import the scenes rendered through their plugin, such as VRay for Revit (*V-Ray for Revit*, 2021) and Chaos Vantage (*Chaos Vantage – Pure ray tracing in real-time | Chaos*, 2022).

There are also plugin solutions dedicated to the world of architecture, allowing, through live synch, to view the model easily. Some examples are Enscape and Lumion (*Lumion 3D Rendering Software | Architectural Visualization*, 2022).

Another possible solution is to import the BIM model using a standard file format into leading software in the sector, such as Unity (Unity, 2022a) and Unreal (*Unreal Engine 5*, 2004). Software houses are increasingly developing plugins to allow BIM users to take advantage of the Real-Time raytraced project visualization through simplified versions of their vertical software in the sector, simplifying the work of the designers. Unity Reflect (Unity, 2022b) is an example of this approach.

Revit VRay and Chaos Vantage

VRay for Revit is a plugin that expands the possibilities of Revit in terms of project visualization. It solves the interaction problems of the photometric solid within the luminaire and can perform lighting analysis on photometric quantities. It has photometrically correct materials, the VRay Materials, which allow importing textures acquired specifically with sRGB profile, thus guaranteeing color consistency in the representations. The software house that developed it has also implemented an application dedicated to real-time visualization, Chaos Vantage. From VRay for Revit, it is possible to export the entire model in a *.VRayscene format, which can then be imported into Chaos Vantage.

In this case, the materials and natural light are managed entirely within VRay for Revit, while the lighting fixtures and photometric files are set up in Revit. Once the file has been imported into Vantage, it is possible to explore the model in Realtime and with the same rendering quality as VRay. It is also possible to apply other materials to the scene, including those previously created and assigned within VRay for Revit. The lighting fixtures can also be switched off and dimmed.

Revit and Enscape

Enscape (*Enscape™*, 2022) is a Real-time Rendering Plugin that can be used in various software, including BIM software and Revit. Once the plugin is installed, it is possible to transport the BIM model to an Enscape instance, establishing a dynamic link between the model and its visualization. Therefore, the Enscape window acts as a Real-Time viewer of everything modified in Revit.

The materials and the lights are then set directly in the BIM software. For this reason, to obtain the consistency between the purchased color and the one represented, the procedure and the precautions are the same to follow to import a color and a texture into the native materials of Revit (Guarini and Rossi, 2019) , taking care to use PBR materials as much as possible. On the influence of the correct simulation of artificial light on color, it is sufficient to follow the recommendations indicated at the beginning of the article. This is generally a valid prerequisite for a solid inserting of lights into the BIM software. On the other hand, the simulations of natural lighting are set directly and dynamically in Enscape.

To have a good representation of the project, the models should be in high detail, i.e. with a high number of polygons, to better represent the curved surfaces and the shades of color on the various finishes. This would, unfortunately, weigh up the BIM file. The Plugin solves this problem by replacing in the representation phase low-detailed Revit families with 3D models developed within an Enscape proprietary Editor. With this expedient, the BIM file is not thought of in terms of Bytes, while the Real-Time representation is shown in high quality.

The Plugin has a custom library containing ready-to-insert templates. If the designer wants to insert models that are not present, he can use the Enscape Editor to import different 3D file formats. This solution allows bypassing the mapping coordinate problems that are present in Revit. The BIM software has a limited set of tools for these purposes but importing a 3D model into the Enscape Editor also imports the mesh mapping coordinates of the imported surfaces, thus solving any problems.

Regarding the color rendering in Enscape, the Plugin can use the Revit materials. However, it also has tools to create dedicated materials, which replace the native materials in the Real-Time window or directly in Revit, if the designer decides to apply them permanently. These materials are configurable within the project and in the Enscape Editor for importing into objects. The basis of the materials that can be created in Enscape is the PBR Materials. Considering this, for the correct color rendering, the texture with the sRGB color profile to be used is the one that must be inserted in the slot generally called “Albedo”, which refers to the light reflected in a diffused way. In addition, if the designer opts to use Revit materials to view the project with Enscape without making any replacements, it is advisable to directly use the PBR materials, already present in Revit since 2019 and as explained at the beginning of this text.

Revit and exporting in dedicated di Real-Time Visualization Software

Another possible way to view the BIM model in interactive mode is the use of vertical applications in this sector, explicitly developed for Real-Time visualization, among which we can mention the best-known "Unity" and "Unreal".

These software also use PBR materials, which are, in fact, the standard for a physically correct representation of materials and their finishes. Taking up and completing what written at the beginning of this text, the parameters present in this type of material are different, but among the leading properties, we can mention: color (or Albedo), roughness and metalness, that is, if the material is a dielectric or metal. These three properties are present in every solution we are presenting here. Each of these affects the final color rendering by the observer, but the one that most significantly affects the perception is the first: the Albedo, which should always be entered with the sRGB color space in case it is assigned as a texture.

Each software may present these parameters differently. For example, in Unreal, the Albedo is named "Basic Color". The interface of the Unreal Material Editor shows an Editor of nodes, which are connected with a tree structure. The various parameters are the nodes, connected to the primary node that represents the material on which the designer is working. In the node relating to the texture to insert "Texture Sample" and connect to the "Basic color" it is possible to choose the texture to use. In the texture properties, it is possible to specify whether the inserted texture should be in the sRGB color space (Fig. 3), and as explained at the beginning of this text, here this option must always be activated.

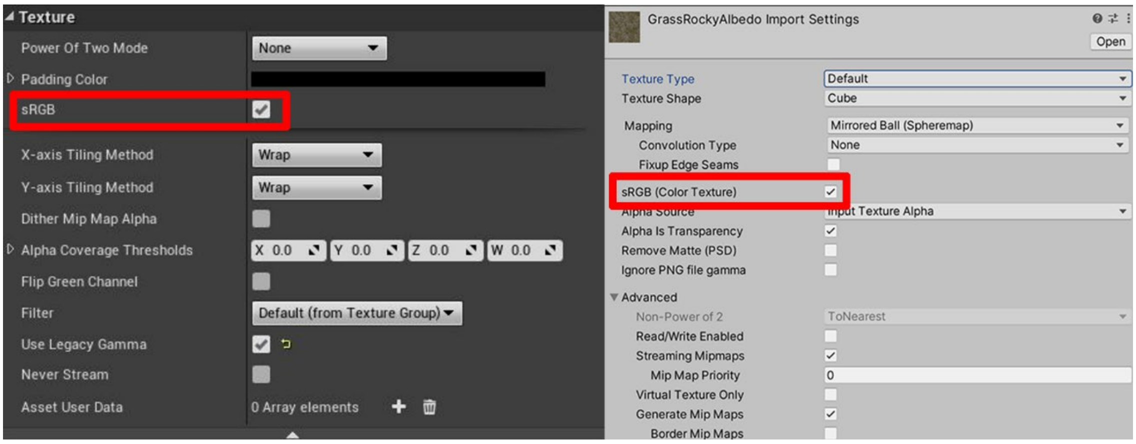

Fig. 3 – sRGB Option in the Texture Properties of Unreal Engine and of Unity

It is possible to develop the procedure for importing the BIM model into Unreal in several ways. The most straightforward and immediate one is using the *.fbx format. However, this is a geometric format, and its use can lead to the loss of many information in the project's BIM database. This problem can be solved using a third-party plugin, such as "Datamisth" (*Datasmith Exporter Plugins*, 2004), which allows to associate information not present after exporting the *.fbx file. This Plugin should be installed on Revit and enabled on Unreal. Using this Plugin, it is possible to keep track of the material replacements made during the import of the *.fbx file, and it is possible to reapply them automatically if it is needed to re-import the model following some modification or variant of the project. This procedure is longer and more complex compared to the Enscape Plugin alone, as it requires several steps and attention from the designer.

The visual render of the BIM model is not so sophisticated because the furniture's level of detail and development cannot have surface models composed of an excessive number of polygons. So even in Unreal, as with Enscape, it is possible to replace the Revit families with more complex geometries to enhance the visual result.

Another Vertical program dedicated to Real-Time Rendering, as Unreal, is Unity. Also in this application, the materials used are PBR, and here too, there is the possibility to specify whether the texture should be used with the sRGB color profile (Fig. 3). If the texture is assigned to the Albedo color, the sRGB profile must always be specified.

Revit and Unity Reflect

As shown in the previous paragraph, the use of vertical software in Real-Time representation guarantees, on the one hand, high-level performance and a great variety of tools for the designer. On the other hand, the export process can be non-intuitive for the designer and increase the number of skills he must acquire to obtain the desired result, discouraging their use. Considering this, some software houses have decided to develop specific versions of their applications dedicated to the BIM world, so that they interface directly with Revit and facilitate the use of these tools by BIM specialists. An example of these dedicated applications is "Unity Reflect", derived from the Unity application. The application installs a new tab in the Revit ribbon, from which it is possible to easily

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export the BIM model to the Unity Reflect viewer. Any changes made in the Revit model, both in the geometry and the material, are automatically updated in the Unity Reflect model. The model imported into the viewer is completed with all BIM data, without the need of third-party export programs. The color properties of the materials, to be consistent, must therefore be correctly set directly in Revit with the advisable use of the PBR material, since Unity Reflect does not have the tools of the central Unity program; it is simply a 3D viewer of the BIM model.

Conclusions

This text illustrates some solutions available today to visualize a BIM model through Real-Time rendering, trying to maintain consistency between the actual colors chosen for the finishes and those represented in the design visualization. It has been explained that to achieve this result it is necessary to respect some preliminary procedures: a) acquire the textures of the materials with standard procedures and periodically calibrated tools, taking care to convert the relative color profile of the devices into the absolute sRGB color space; b) correctly simulate the possible lighting conditions; c) preferably use the recent PBR materials, if possible, already within the BIM software.

The BIM software does not have a module dedicated to Real-Time. A first solution could be using the VRay for Revit plugin, which in addition to creating traditional professional renderings, can export the scene to the Chaos Vantage Real-Time application of the same software house. Another solution is using other rendering engines such as Enscape or Lumion, which allow a live connection with the BIM software through a special plugin for Revit. It is also possible to export the BIM model to programs specifically dedicated to the Game Engine and Real-Time Visualization, such as Unreal and Unity. Finally, we can mention the possibility of using specific BIM versions of previously listed vertical Real-Time software, such as Unity Reflect.

These are just some of the possible solutions in the designer's toolset, which vary in terms of typology and applications available. Indeed, with the evolution of current technologies in a dynamic and rapidly expanding field, we hope that there will be a convergence towards a reduced number of solutions for professionals in the future.

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3. Color and Lighting

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A possible new method for Forensic Document examination: Plasmonic colors

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Abstract

In the examination of forensic documents, it may be necessary to examine the document by various methods. It is one of the important methods to reveal the features that exist in the document but are not visible enough or not at all in visible light with various optical methods. Conventionally, the light falling on the document from a light source or the filtering of the available light are used singly or in combination. Another conventional method for the perception of colors is pigments. They create a color perception according to the light that is absorbed and reflected according to the incident light. Plasmonic colors are associated with surface plasmon resonance. Surface plasmon resonance is the resonance oscillation that occurs at the interface between the negative and positive permeability material, which is caused by the excitation of transmission light electrons in metals or photonic crystals with incident light. Thus, colors can be created without pigment and without the need for an additional light source. In recent decades, it has been used industrially with the development of nanotechnology and software technology. The possible use of this method in Forensic Document review is examined. The formation of plasmonic colors with liquid crystals can cause rapid color changes in the skin of some animals in nature. Thanks to nanotechnology and software technology, similar liquid crystals can be created artificially. Since only ambient light is used in the formation of liquid crystals and plasmonic color, additional light sources are not required for pigments or light color vision. These features can become a significant advantage during forensic document review. A nanotechnological liquid crystal layer to be applied on the document or a liquid crystal layer that will only be leaned against the document can create different and various colors depending on the characteristics of the document surface and substrates. Optional adjustable changing of perimeter beams can also be used as a separate parameter in forensic document examination. The fact that no pigment is required in plasmonic color rendering ensures that the originality of the document is not damaged. Using only ambient light also reduces possible radial damage to the forensic document. With the plasmonic color technology, document structure information that could not be obtained until now can be accessed with the least damage to the document.

Keywords: Forensic document, light source, liquid crystal, nanotechnology, plasmonic colors

Introduction

Conventional color production is made by light or pigments. Colors in light is additive and in pigments substractive. Plasmonic color is a subset of structural color, which is color resulting when the micro- or nanostructure of a material causes light scattering and interference. Plasmonic colors have some different features than the conventional colors. They are no dyes, but they build colors with unconventional characteristics, which may look like dyes. Its unique features can be used in forensic document examinations.

Forensic document examination

In forensic document examination one can use many lighting techniques and light characteristics, to make details to be "seen" which cannot be seen to "naked" human eye. Light features like direction, polarization, colour etc. are mostly used in combination to have conventional techniques and machines. Even techniques like of circularly polarized luminescence for advanced security inks are still conventional colour and light features (MacKenzie 2021). The characteristics of plasmonic colours may be a game changer in forensic document examination methods.

Plasmonic colours

Stained glass is known for more than 5 centuries. The underlying technology on molecular level is understood in the last decades. The color is produced through the ambient light in glass with metals and their salts.

In the plasmonic color technology today mostly metals like gold, silver and aluminum as atoms are used. The distance between the atoms, their heights and their arrangement determine the wavelength of resulting light, so the color. So in a set where these parameters can be changed, different colors can be produced with the same set.

Photonic colors are found in the nature, also. Teyssier (2015) showed in his study that the color change of chameleons are achieved through changes in photonic crystals. Plasmonic and photonic color effects are found also in the wings butterflies like flip-flopping (Lee, 2018 ; Barrera-Patiño 2020).

Colored electronic paper is produced mimicking the natural photonic crystals and plasmonic colors adding display technology to it. Displays are an indispensable medium to visually convey information in our daily life. Although conventional dye-based color displays have been rigorously advanced by world leading companies, color fading and wavelength-limited resolution restrict further developments. Plasmonic colors emerging from resonant interactions between light and metallic nanostructures can overcome these restrictions. With dynamic characteristics enabled by functional materials, dynamic plasmonic coloration may find a variety of applications in display technologies. Dynamic controls endowed by functional materials, including magnesium, liquid crystals, electrochromic polymers, and phase change materials are advantageous (Neubrech et al 2020).

Color can be produced through all these technologies. Plasmonic colors may be even “printed” with metals (Wilson, 2019). Because they are in atomic level, they can be printed in nano- or micrometer scales.

By adapting the geometry and composition of the nanorods (Au and Au@Ag) light modulation in a significant portion of the visible and infrared spectrum (600-2400 nm) can be achieved. This is very fast (~30 µs) and reversible nanorod alignment can change the color very fast. So significant color changes characterized by observed chromaticity and luminance shifts. With the use of polarisation in plasmonic systems two different colors can be produced at the same time (Greybush 2019).

With the use of artificial intelligence and deep learning through artificial neural networks laser parameters vs. colors and geometric parameters vs. colors can be determined. With reverse geometry geometric parameters and the laser parameters are predicted from color (Baxter 2021).

Hong (2019) found that in the near and mid infrared ranges capable of simultaneous multi-spectral sensing can be achieved with a hybrid metal-graphene plasmonic sensor. That may enable complicated measurements which are difficult with conventional color technology.

All these technologies can enhance the examination of forensic documents which are produced with conventional methods. On the other hand the use of plasmonic colors in documents may change all forensic evaluation.

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Conclusions

Plasmonic colours use generally the available light around it. So color (as light) can be created without additional lighting.. Less light (lighting) pollution occurs around it, so that its detection would be better. It can be also produced as a laser . Plasmonic colors can be combined with different features like polarisation and other light characteristics. Two or more colors can be created simultaneously. All these features may be very useful in evaluating forensic documents.

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Twilight | Spatial Experiments

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Abstract

Twilight is a term that immediately evokes images and atmospheres of those lighting situations that occur naturally in the morning and evening during dusk or down, or they are artificially created through art projects. Sometimes these dramatic situations of devided light threshold experiences are connected to light and darkness, waking and sleeping or even life and death. There is no clear line of demarcation to be drawn, one way or the other, as the twilight is neither immediate nor abrupt in its ending. Bernhard Waldenfels speaks of a “dividing zone” with a certain extent, which one can hesitantly enter and linger waiting before entering another space or condition. It is a certain waiting status that spreads between a no longer and a not yet (Waldenfels, 2013).

The LightLab at the Institute for Spatial Design at Graz University of Technology deals to sensitize students in the field of light and space in architectural education. During winter semester 2019/20 the LightLab established a cooperation with the association mehr licht. Within this context of collaboration, we established a four-day workshop dealing with the subject of twilight for TU Graz students attending the course Spatial Experiments. During the short but intensive work phase, the students created drafts for spatial installations and their concrete implementation inside the castle-hill Schlossberg Graz. The castle hill Schlossberg is a hill in the middle of the historic center of Graz and the citys landmark. We concentrated with our students of the interior path through the Schlossberg and its caves inside, which is a former air raid shelter from the times of the second world war. The students developed interventions in the tunnels using sources from the institute, set pieces such as color filters, various materials, fabrics, strips of paper, etc.

Keywords: color, light, material, spatial perception, space

Introduction

.. There is something mystical about wandering through the forest. A path that is characterized by its density and openness, by a play of light and shadow.

... Play of light nothing stays the same, a back and forth of perception and mood. Everything seems the same but still it is different...

From the notes of two different groups of students.

The twilight is ambiguous in its terminology. As a rule, it is equated with twilight and is including some optical phenomena that can show up in intensive color perceptions in the respective geographical and temporal day-night boundary.

In addition to the natural phenomenon of twilight, it also describes the urban atmosphere, which is often brief, when, for example, the color temperature of the artificial street lighting can be consciously perceived in contrast to the bluish and dark sky. It is the contrast phenomenon itself, for which there is no clear description, that characterizes the twilight, independent of a light source or light reflection. Figuratively, the term twilight involves doubtfulness and ambiguity about a situation or person. Therefore, twilight denotes both the ambiguity of the lighting conditions and, symbolically, the morally dubious appearance of a person and, moreover, an eerie mood.

Twilight is an everyday phenomenon that we take for granted in the daily alternation of day and night. It appears as a light phenomenon in many forms during dawn or dusk. From a scientific point of view, the description of the rotation of the planet around its own axis in the presence of the sun and a light-scattering atmosphere is sufficient for a simple classification. By definition, we are looking at a period of about two hours - the exact duration depends on the latitude and the height of the sun. These phases are described in terms of a so-called depth angle, which indicates the deviation from the horizontal of the horizon. The optical phenomena that occur, which we encounter as light phenomena such as "counter-dawn", "alpine glow" or "blue hour", are individual phenomena in the reservoir of twilight and thematically fuel modern photography and art in particular.

No other painter in the 19th century was able to capture this atmosphere of uncertainty, vagueness, nature and culture as aptly as William Turner. Although rooted in his time, his form already paved the way for modernism. His themes are still committed to nature and representationalism, while in his later phase the style of painting concentrates on the effect of the colors and the motifs dissolve into almost complete abstraction. The picture "Sunrise with Sea Monsters", created in Margate in 1845, shows the picture surface in a beige-brown-gold color mood shortly before sunrise. The materiality of air and water seems to be in motion and dissolving. *"Through the coloring, the whole picture gives the impression of flowing"* (Schmidt, 2001). The existence of the aforementioned sea monsters in the middle of the picture could be just as real as the expression of a deep-seated, unconscious fear that seeks a manifestation in the twilight.

The abandonment of the connection between perception and truth, which since the 17th century, beginning with Descartes' rationalism, the scientification of the world view and the establishment of a modern, enlightened subject, has been taking place successively and at the end of the 19th century explosively, also forms for the beginning of modern art completely new conditions and freedoms. The composition of the picture and the colourfulness abruptly eluded the rules of established salon painting. The most radical painter of the upheaval is perhaps Claude Monet, the master of lighting moods and atmospheres. His 1872 Impression, Sunrise, a twilight scene in the port of Le Havre, gives the new art style its name. Unexpected are not only the picture detail, technique and colourfulness, but also the seriality that appears from 1890 onwards. In total there are 33 depictions of the west façade of Rouen Cathedral, slightly shifted from the point of view of the painter and at all times of the day and lighting moods. In addition to the seemingly arbitrary picture section, the lack of distance between the painter and the object as well as the color slowly separating from the object, it is above all the gesture of the series that completely negates the uniqueness of the work of art and the illustration. The pictures, some very three-dimensional due to deep shadows, others blurred in the twilight, seem to report more on the painter's emotional world than on a specific object. Monet himself describes it with the words: *"I want to convey what I feel in front of the motif."* (Sagner, 2005).

In this context, the so-called "Roden Crater" by James Turrell, a representative of American land art and light art, has a monumental design, inside which Turrell visualizes and spatially examines the various cycles of the sun, moon and stars. In another work by the artist, twilight comes into focus as the primary artificial medium: "Skyspace The Other Horizon". The installation in the park of the Geymüllerschlössel, realized especially for the MAK 2004, consists of a constructed room, which opens upwards to a roof and thus reveals a partial section of the sky. The MAK description of the installation says: *"The most impressive effects are achieved at dusk."* (Turrell, 2001) And indeed: Turrell defines a precisely defined time window in which the installation can be viewed - as further described in the description means: *"90 minutes before sunset until nightfall."* (Turrell, 2001) Another "Skyspace" from this series of works by the artist of the same name can be found in Lech am Arlberg - the description of the work states: *"As twilight falls, the walls and the ceiling of the*

Skyspace-Lech are bathed in color-changing light. The sky may then be perceived as part of the room through the opening." (Verein Horizon Field, 2022) Here, the twilight is explicitly explored in terms of its material qualities – it is no longer just a component of the work, but working with its ephemerality as a conceptual and aesthetic basis.

The twilight is actually a constitutive part of architecture, like the walls and the roof. There is always twilight inside rooms. The artificial light mixes with the natural light that comes through the windows. Before the invention of the gas lamp and later the light bulb, the options for influencing the lighting atmosphere in buildings were limited and dependent on daylight and the technical possibilities for glass production. In the Middle Ages, the lack of artificial light gave rise to a competition between the cathedrals, fed by belief in God, striving for power and technical developments aimed at dematerialization. The deep and high church rooms - here again as a metaphor for the world as a whole - remain in a peculiarly floating and mystical atmosphere of semi-darkness, despite the ever larger wall openings, broken only by rays of light that an invisible sun projects into the interior through the colored glass windows.

Interestingly, many modern architects in church building resort to the gesture of a mystical twilight, but not to the dematerialized walls of the High Middle Ages. In Le Corbusier's iconic work Chapelle Notre-Dame-du Haut de Ronchamp, the lighting effect is primarily determined by the double-curved, white-plastered concrete wall of the south façade and the narrow slit of light from the floating concrete roof. The wall thickness of the south wall is up to 2.7 meters and is broken through by 27 rectangular window openings of different sizes, some with colored glass. In fact, the atmosphere of the interior cannot be described, it can only be experienced. The atmosphere of direct rays of light, indirectly radiating reveals and colors can actually only be enjoyed in silence.

Both brightness and darkness can arise from the twilight. There is a perception of beauty and horror and in the metaphorical sense - where man relates the twilight to himself and his existence - also something contingent or destiny.

Transfoming Space

The workshop spatial experiments is held annually at different locations and with changing tasks. For the majority of the students, this course represents the first contact with the topic "Light and Color in Architecture". The aim of the workshop is to imagine spatial constellations and atmospheres in an experimental way and to work with the immaterial factors space, light and color. The students experience an initial sensitization to the topic and are guided to implement designs with simple technical means.

These spatial experiments took place in a four-day workshop in the LightLab of the Institute of Spatial Design at Graz University of Technology and in the *Schlossbergstollen* in Graz. The attraction of the place lies in its total darkness and the suppression of any external influences. This promotes also concentration on the task.

In the workshop, different approaches to the design will be tried out. An important tool in architectural production is to check the design by using models. Sometimes parts of spaces have to be prefabricated in a scale of 1:1. Working in situ is another efficient way of exploring different spatial situations moods and atmospheres, testing under "real" conditions,

The subject of this spatial experiments was dealing with the topic of twilight. It was divided into two sections. In the first step, the students were given a guided tour of the *Schlossbergstollen* to get an overview of the site. In the LightLab, the basics of "light, color and perception in theory and practice" were taught as well as practical handling with luminaires.

Fig. 1,2,3,4 – LightLab: Experimenting with Light, Color and Material

The goal of the first two days was to develop a basic concept for the implementation of the project in the *Schlossbergstollen*. While the main part of the workshop was to advance the experiment in the *Schlossbergstollen*. The students were challenged to appropriate the specific spatial conditions and try to implement their project ideas with the chosen means.

The Site

The castle hill Schlossberg is situated in the middle of the historic center of Graz and the citys landmark. The *Schlossbergstollen*, an interior path through the Schlossberg is an undefined, historical enclave in the city center. It is a connecting path between Schlossbergplatz and Karmelitenplatz – and a twilight zone with an obscure and undefined destination. In the twilight an ocean of thoughts and associations can open for an attentive observer. Inspired by the specific, dense atmosphere and history of the *Stollen*, the association *mehr licht* arosed the idea to use it as an exhibition space to create an artistic discourse and to make art tangible for all. An impeccable public space to spin contemporary art. An artistic think-tank without boundary, where the possibilities to engage audiences with art are unending. And finally, an archetypal environment for working with light in public space.

To work with the students we concentrated of the interior path through the Schlossberg and its caves: A former air raid shelter in the times of second world war.

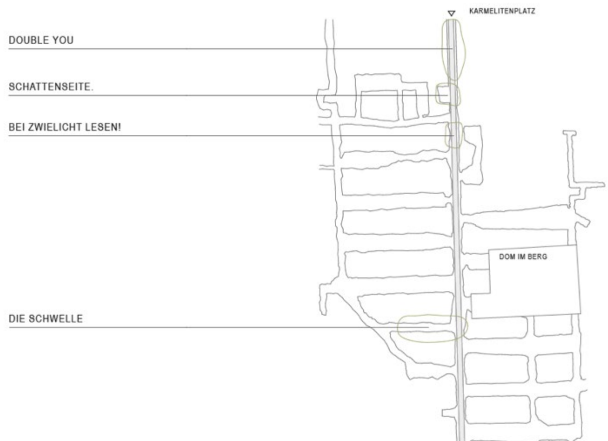

Fig. 5- *Schlossbergstollen* Graz, the interior path through the Schlossberg and its caves

Projects



Fig. 6 left - Lighting Forest, Fig. 7 - middle: The Threshold, Fig. 8 - right: Reading in Twilight

Five projects were created at different locations (Fig. 5) in the Schlossbergstollen, two are briefly presented in this paper.

LIGHTING FOREST

The project (Fig. 6) dealt with the theme of the strip through the forest, the gentle blowing of the wind through the branches and the thicket, the play of light colors and shadows and the associated changes in perception and mood. The first cave on the right side of Schlossbergplatz was chosen as location for the installation. It fascinated the students because of its elusive, uncertain depth. The cave is approximately 3.5 meters wide, between 2.5 and 3.6 meters high and 8.5 meters deep. There is a metal net on the ceiling which is intended to prevent loose material from falling off.

For the project, 250 strips of three different lengths were cut out of white cardboard and attached to the metal grid on the cave's ceiling. Experiments followed with different lights, playing with distances of the strips, light and color. Various atmospheres were created and tested inside the cave.



Fig. 9,10,11: Lighting Forest

Equipment: 2 profile spotlights - ETC Source Four Junior (575 Watt), 2 dimmers Zero 88 Alphapack, 1 fan

The light-space installation was backlit by two spotlights with warm and cold light, and a fan made the stripes move.

THE THRESHOLD

"Whoever stands in front of a threshold already anticipates the coming transformation, the opening of the new. Anyone who stands on the threshold can go back, but at the same time is in a state of open determinability both forwards and backwards. Anyone who has crossed a threshold remains the same, but has also become someone else." (Saul, 1999)

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The association with the threshold arosed for this project (Fig. 7) through the intensive examination of the subject of twilight. This spatial light experiment describes a liminal experience as a zone of change and transforms those who are exposed to it and live through it. Through the light as an irritation, the viewer approaches the threshold experience.

At the beginning of the experiment in the cave, different light colors and positions of the lights were experimented and the depth of the cave was explored. As the final project, two light situations were presented that flowed into one another. This was preceded by numerous experiments with lighting control.

Fig. 12,13,14: The Threshold

Equipment: 1 profile spotlight - ETC Source Four Junior (575 Watt), 2 dimmers Zero 88 Alphapack, 4 LED RGBW bars ADJ UB 9H, Enzzec ODE MK2, WLAN router

In the cave, the profile spotlight produced a large-area, even light distribution with a reddish to warm white light color. The four LED bars were set up at an angle of approx. 30 degrees with an even spacing, creating a cold white, flat light. All lights were controlled via a Wifi DMX mobile app.

Results and Discussion

The main topic of almost all projects was the transformation of the spatial condition inside the different caves. Another important issue was the change the found situation into artificial light conditions with its changes from dask till dawn. Through intensive work and analysing of the spatial qualities of the chosen caves the students were made aware of spatial perception when light and colour conditions changed. With understanding the scale the students began to develop their own way of working with the topic of light and colour. Starting with their own experiences during the laboratory conditions the students started step by step including light in their projects. The results were interpretations of twilight situations and the transformation of space was thought together with light.

Conclusions

The focus was to abstract experienced spatial conditions and transform them inside the *Schlossbergstollen*. The main actor in this play was the appearance of light and color inside a cave. Through discussions about their gained experiences, perceived thoughts and feelings they could explore different spatial conditions with the help of light and colour. The selected colours were mostly

used for changing the natural light conditions. The experience enabled the students to get a deeper understanding of architectural design processes and led them to a more critical reflection about light and space.

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The open issue of color management in circadian interior design between the practice of lighting and color design

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Abstract

In the last 20 years, research has been developed in the field of chronobiology and physiology to demonstrate the relationship between the health of the human organism and the light radiation that enters our eyes. These are known as the Non-Image Forming (NIF) effects of light. Nowadays, it has been scientifically shown that light radiation's parameters that affect our physiology are the quantity, the spectrum, and the time of exposure. These fundamental parameters impact our living in interiors, illuminated by artificial light, with scarce or no natural lighting. Until a few years ago, in the design field, there was a lot of skepticism about these aspects that the 2017 Nobel Prizes in Medicine genetically demonstrated. Today there is a growing interest developed in the lighting design sector, which, however, sees the need to deal with a holistic interior design vision. In this article, a review of current knowledge is proposed to favor the relationship between lighting and color design.

Keywords: interior design, lighting, color, circadian.

Introduction

In the last 200 years, human life has transformed with mass migration from the countryside to urban centers and the industrial revolution. In a few generations, we moved from a working life conducted outdoors, in the country, to one mainly indoors, with a limited supply of natural light and exposed instead to artificial light. We should remember that in Europe, in 1800, only 2% of the population lived in cities. In the early 1900s, this had risen to 15%. In the 21st century, most of the European population lives in cities (UNICEF, 2008) and works in closed spaces; most of those living outside urban centers do not work outdoors. It is estimated that in today's industrialized societies, we spend between 80% and 90% of our time indoors (Evans, 2003; Boubekri, 2008). Indeed, our body is made to function and synchronize itself according to the rhythm of the continuous variations of natural light. Our physiology would require exposure to natural light during the day and complete darkness at night to promote sleep, with its regenerative cycles fundamental for health, happiness, and wellness (CIE, 2001).

In the interiors, the light and colors of the perceived image are entirely different from the open-air ones, in which we have evolved for millions of years. The change in the environments in which we live and our exposure to artificial lighting are both factors that have been introduced very recently (Stevens, 1987). With the 2017 Nobel Prize in Medicine (Young, 2017) awarded to Hall, Rosbash, and Young, the issue of circadian effects on people's well-being in interiors has been brought to the attention of industry manufacturers and innovation-minded designers (Figueiro, Nagare and Price, 2018).

The circadian system

The word "circadian", composed of the Latin words circa and diem, describes a periodic biological cycle that lasts roughly one day (Halberg et al., 2003). In the human organism, there is a timed system that lasts about 24 hours, managed by the suprachiasmatic nucleus in the innermost and primitive part of the brain, through which all the physiological processes, such as sleep and cell regeneration, hormone production, blood pressure, body temperature, nutrition and digestion, alertness, coordination, and muscle strength, are managed (Klein, Moore and Reppert, 1991). The

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human body is made to function and synchronize according to the rhythm of the continuous variations of natural light (Czeisler et al., 1981). Our physiology requires us to be exposed to natural light during the day and complete darkness at night, promote sleep, a fundamental function for health, and ensure the proper phasing of our circadian rhythm (Wright et al., 2013). Some lighting designers try to mimic the behavior of natural lighting with indoor artificial lighting.

Many situations can disrupt our circadian rhythm. A known factor is, for example, flights between multiple time zones. Jet lag occurs due to the phase shift between the sleep cycle, internal organs, and the new circadian rhythm induced on the body by the different timing of the received lighting (Boulos et al., 1995). The social context, such as night shift work (Eastman et al., 1995), can also lead people to excessive evening light exposure, consciously or otherwise, contributing to a delayed phase shift in the circadian rhythm, defined as social jet lag (Joo et al., 2017).

Sleep disorders could be caused by circadian rhythm disruption and are often underestimated by general medicine (Institute of Medicine (US) Committee on Sleep Medicine and Research, 2006). Disruption of the circadian rhythm can occur in delay, DSPD (delayed sleep phase disorder), or in advance, ASPD (advanced sleep phase disorder) (Phillips, 2009). These phase shifts could become pathological. Research has shown that circadian cycle disruption can cause migraines (van Oosterhout et al., 2018), headaches (Pringsheim, 2002), irritability (Evans and Davidson, 2013), night (Bach et al., 2019) and daytime (Jokubauskas et al., 2019) bruxism, seasonal depression (Rosenthal, 2006), immune system deficiencies (Christoffersson et al., 2014), chronic fatigue (Bonsall and Harrington, 2013), obesity (Reiter et al., 2012) and diabetes mellitus (Cedernaes, Schiöth and Benedict, 2015). There is also discussion of an increased likelihood of developing certain types of tumors due to the weakening of the immune system (Stevens et al., 1992; Schernhammer et al., 2003, 2013).

Artificial Circadian Lighting

Why not use artificial lighting indoors to phase our circadian rhythm correctly? While the idea may seem valid and healthy, the design approach is often weak (Figueiro, Gonzales and Pedler, 2016). Being this an ongoing field of research. Some methods of light evaluation have been included in specific national standards without design guidelines (IES, 2018; DIN, 2021). Although there are no reference standards in this field, some basic design guidelines can be drawn to improve our life indoors. We can define some features that the lighting system should have to be considered circadian:

- Indoor artificial lighting in interiors should be dynamic, with quantity and CCT varying throughout the day, similar to natural light variations.
- In the phases of relaxation and evening, it is advisable to use a warm CCT with low lighting levels to avoid disrupting our circadian cycle.
- To promote the proper phasing of the circadian rhythm, lighting in the first half of the morning and the first half of the afternoon should be higher and have a cooler CCT.
- Today, in the absence of specific standards, to determine if the light reaching the eyes has circadian effects, the reference model proposed by (Rea, Nagare and Figueiro, 2021) can be used and calculated using software tools available online (LRC, 2018; OSRAM SYLVANIA, 2018).
- Light sources with high color rendering should always be preferred. The actual color rendering should be evaluated using the TM-30-20 standard.

Anyway, a lighting product or lighting design is not enough to stimulate the circadian system properly. It is the design of the environment as a whole that must be circadian because we always instinctively avoid looking directly at light sources because of glare. Instead, we are constantly observing the surfaces of the environment around us with their colors.

The "surface color" factor

We must remember that, from the design point of view, the light that reaches the users' eyes must be evaluated because it is the only aspect that affects the circadian system. So, the spaces, expected human positions, and activities must be analyzed in detail. The light that our eyes receive, and which contributes to the visual system as well as the circadian system, is almost always diffused light from the surfaces of the environment, which in turn have physical characteristics that reflect to our eyes light generally modified by the light spectrum coming out of the luminaires. The main studies (Brainard *et al.*, 2001; Thapan, Arendt and Skene, 2001) on the response curves of the circadian system were done in a laboratory, with dilated pupils and a fixed gaze inside a Ganzfeld sphere, with nearly monochromatic lights projected. These experiments lack any contribution from spectral reflectance of our everyday life and how they really reflect light to our eyes.

Within this context, the NIF effects on people's mood and pleasantness (Veitch and Newsham, 1998; Borisuit *et al.*, 2015) attributed to CCT will also come into play. Anyway (Boyce and Cuttle, 1990) more correctly observed that the evaluation of the interior space does not depend only on the CCT of the light but also on the other natural and colored elements that may be present. The aspect lacking in evaluating circadian effects is the color in the surfaces of interiors and furniture, that is, what human eyes watch in that 80-90% of the time they spend indoors.

For the design application, a correct evaluation of circadian effects implies considering the colors of the interiors and the way they modify the perceived light (Bellia, Pedace and Fragliasso, 2017). Some studies have been done using color samples or computer images which are difficult to transfer to the design field (Anter and Billger, 2010), while other studies have been done in the field (Kwallek *et al.*, 1996; Küller *et al.*, 2006; Hårleman, Werner and Billger, 2007; AL-Ayash *et al.*, 2015; López-Tarruella *et al.*, 2019) with variations that may also be of cultural origin (Hogg *et al.*, 1979; Ou *et al.*, 2018)

Conclusions

From the point of view of interior architectural design, there is a total absence of tools that allow us to design light and color together. Tools would be needed to calculate and quantify the interaction between lighting and surface colors to evaluate the light's characteristics that reach users' eyes from a quantitative and spectral point of view. These new tools should hopefully be developed within the Building Information Modeling methodology to enable the integrated design of light and color. However, today only the photometric data of the light sources are starting to be available in BIM; the spectral data (Rossi, 2022) and those concerning the spectral reflectance of the authentic materials used in Interior Design are still missing (Guarini and Rossi, 2021)

This paper presents a short review for bridging the gap between lighting and color design, trying to enter partly into the field of a new interior circadian design to simulate natural lighting and the environment best. There is, therefore, a need to carry out more research in the field to be able to assess human beings in real-life settings, also considering the time factor (Figueiro, 2013), with the dynamic and chromatic variability that LEDs can have today (Wang *et al.*, 2014).

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Colorimetric analysis and color rendering performance of a small-scale glazing system with thin monolithic aerogel in the interspace.

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Abstract
Transparent surfaces in buildings ensure natural light into indoor spaces and allow energy saving, reducing consumptions for artificial light, and the occupants' psychophysical well-being. For this reason, color rendering lit by the natural light entering the windows is a major concern. However glazing surfaces represent a weak point for the building envelope, due to poor thermal and acoustic performance. Monolithic aerogel constitutes a promising transparent solution, able to guarantee excellent thermal and acoustic properties, together with remarkable optical performance. In the perspective, this paper focuses on the analysis of the optical properties and the color rendering performance of a small-scale prototype consisting of float glass-monolithic aerogel-low-e glass. The aerogel inner pane, 3-mm-thick, was prepared using a rapid supercritical extraction method developed at the Union College Aerogel Lab. Optical measurements carried out using a conventional spectrophotometer with a small integrating sphere in the 250-2500 nm wavelength range, indicate high transmittance in the visible part of the spectrum. As concerns color rendering, an original measurement methodology based on material transmission spectra was developed through the use of chromatic distortions verified on an experimental basis. Although the traditional calculation procedure for transparent components considers the color rendering of the object illuminated by the light transmitted through the element, the explained one involves the evaluation of the color observed through the transparent material. The effect of the glazing system with aerogel on color rendering was assessed by means of a dome-shape illuminator, a chromameter, and a color-checker as a reference for the colors. The RGB and CIE Lab coordinates of the test color samples of the color-checker with and without the aerogel were used to calculate the color shift. The results showed that the glazing system tends to make the colors brighter and to move them towards blue hues. Then a new color rendering index, identified as $R_{a,p}$ (proposed Color Rendering Index), was calculated. Finally for the innovative glazing system also the Color Rendering Index R_a in accordance to EN ISO 410 was evaluated, to compare the results of the two procedures.

Keywords: monolithic silica aerogel, glazing systems, optical properties, color rendering, color shift

Introduction

During last century, glass achieved an increasing important role in the construction sector. It connotes entire facades of residential and public buildings, thanks to the relevance attributed to its ability to allow the natural light entering into the indoor environments, to optimize the visual comfort of the occupants and the perception of connection between interior and exterior, and to reduce energy consumptions for artificial lighting. Anyway glazing surfaces are in charge of 37% of the total cooling energy consumption related to summer solar radiation, and of 40% of the total building thermal losses during the winter. Furthermore solar radiation could cause direct glare and reflection, whereas transparency could be associated to a not optimal color rendering. In order to solve these problems, over the years glazing systems have undergone continuous technological developments to improve performance. Solutions directly related to transparent surfaces, such as low-emissivity glass, solar-controlled and selective glass, have been replaced by scientific interest in the production of innovative materials applicable both in new buildings and in the retrofit interventions of existing ones (Jelle *et al.,* 2012). Aerogel represents an attractive material for high performance windows, making it possible to achieve adequate comfort conditions, both from the thermal and acoustic point of view, but especially from the optical/visual and chromatic point of view, while reducing the building's energy consumption (Buratti *et al.,* 2021). It could be produced in translucent granules and transparent monoliths, depending on the chosen drying method (Buratti (Ed.), 2019; Aegerter *et al.*, 2022) . These last two forms have promising optical properties, especially visible transmittance in the 0.58–0.75 range (Moretti *et al.,* 2019), ensuring a good transmission of diffused light within the indoor environment, absorption of infrared radiation and avoiding annoying glare, when inserted as insulating material between two glasses for the realization of high efficiency windows. Such properties allow for significant energy saving by reducing the consumption for heating while maintaining good natural lighting conditions, making aerogels glazing systems particularly appealing for use in cold climates (Baetens *et al.*, 2011; Moretti *et al.,* 2019; Tao *et al.*, 2016; Belloni *et al.* 2021; Buratti *et al.* 2020).

Unlike the granules (Buratti and Moretti, 2012; Ihara *et al.*, 2015; Carroll *et al.* 2022), the monolithic form it is not currently available on the market, due to the difficulty of making large homogeneous slabs at reasonable cost, but it ensures better optical performance than granules, especially when the transparency is mandatory.

Despite the superior insulating ability, monolithic silica aerogel does not have the optical clarity of glass employed for windows, due to light scattering, already noticed by Duer and Svendsen (1998) and the surface imperfections which often make the material poorly finished/rough. Some proposals to improve transparency include variation of quantities and proportions of chemical precursors, thickness reduction, and heat treatment (Carroll *et al.*, 2022).

As for the domain of colorimetry, the debate on the approach to color rendering that has characterized the last decade, also concerns the transparent components. For color rendering evaluation, the Commission Internationale de l'Eclairage (CIE) introduced in CIE 13.3-1995 (CIE, 1995) the CRI (R_a) general color rendering index parameter, which is also the only metric widely adopted in many standards and specifications, including the EN 410 (CEN, 2011). It allows to express synthetically a quantitative evaluation of the differences between 8 standard sample colours, lighted first directly by the reference light source, the illuminant D_{65}, then by the same illuminant, transmitted through the glazing. However, this metric suffers from some well-known deficiencies, such as fewer test color samples (TCSs), an outdated chromatic adaptation transform (CAT), a no-uniform color space, and confusing negative scores (Zhang, 2020). This leads R_a to be inaccurate in its intended role as a color fidelity index, as well as not being representative of perception-related color quality effects. As a result, a variety of efforts were devoted to improving or even replacing the CIE CRI (Davis and Ohno, 2010; Hashimoto *et al.*, 2007, Smet *et al.,* 2013).The Illuminating Engineering Society of Nord America (IES) published in TM-30-15 (IES, 2015) a two-measure method, including color fidelity index (R_f) and color gamut index (R_g). The former (R_f) quantifies color quality: the accuracy with which the color appearances of illuminated objects matches their appearances under the reference illuminant. Instead of using eight Test Color Samples (TCS), the IES-TM 30-15 method incorporates 99 Color Evaluation Samples (CES), which provide a more uniform distribution in the three dimensions of a uniform color space. Perception/preference effects are taken into account by R_g. CIE 224:2017 (CIE, 2017) introduced general color fidelity index (R_f), largely keeping with the Fidelity Index (R_f) calculation of TM-30-15 (IES, 2015); the metrics were harmonized with the update of IES TM-30-18. In the case of transparent components, the illuminant under consideration is the same reference illuminant, transmitted through a glazing. In several researches the effect of fenestration component on the spectral composition of the transmitted light and on the related color rendition of interiors was

investigated (Vossen *et al.*, 2016), but almost all of them use method and index outdated, which returns in partial results. Recently Aste et al. (2016) proposed the assessment of the color rendering performance of advanced dynamic windows by applying both the traditional CIE CRI and the recent two-metrics IES TM 30-15 methodologies. The work highlighted the role of two chromaticity difference parameters introduced by CIE 1995 in evaluating the accuracy of color rendition results: DC and Duv. Kuhn et al. (2016) proposed the definition of a new criterion R_{a_out-in} to evaluate the color rendering of objects in a room viewed by an observer who is outdoors. They applied the EN 410 calculation methodology for R_a with the difference that the transmittance of the glazing τ was substituted by τ^2 in all equations, since the double crossing of the incident light through the glazing. A discussion about an extension of the range of test colors by addition of strongly saturated test colors is also included in the paper. The test colors 9–14 CIE 13.3 (CIE, 1995) and the corresponding specific indexes R_9 to R_{14} were excluded from the general color rendering index R_a in EN 410, underweighting the rendering of saturated colors. This leads to unreliable results, especially when considering illuminants like LEDs, which typically reach R_a > 80, but often R_9 << 50.
In the present paper the color rendition evaluation methodology developed in previous works (Buratti, *et al.*, 2020) was applied to double glazing systems "float - gap - low-e" without and with aerogel in the gap, to determine the effects of the insertion of a thin monolithic layer (0.29 cm) of this material with high thermal performance in traditional glazing systems. Optical and colorimetric analysis was preliminary carried out on monolithic aerogel samples and on each of the glass panes used to assemble the window prototypes, in order to estimate their color rendering properties. To assess the reliability of the new method, the results obtained, in terms of of chromatic divergence (ΔE) and Color Rendering Index (R_a) were compared to those obtained following the standard EN 410.

Materials and methods

Thin aerogel monoliths' background: expectation and preparation procedure

The approach deepened in the present work is to improve the optical clarity through the reduction of the material thickness. The aerogel is made with a sol-gel process, starting from a silica precursor, usually an alkoxide asr tetramethyl orthosilicate (TMOS) or tetraethylorthosilicate (TEOS). It is mixed with a water/solvent mixture and then an acid or basic catalyst is added. The mixture first experiences hydrolysis, generating a sol, followed by condensation reactions from which a wet silica gel is obtained, then the process ends with a careful drying, in order to avoid or to limit the shrinkage.
In this work tetramethyl orthosilicate (TMOS) was used as the silica precursor, methanol and deionized water (DI) as solvents, and 1.5 M aqueous ammonia, prepared via dilution of methanol with DI water, as catalyst (Table 1 – Recipe A1 per 1.27 cm thick aerogel, Recipe B2 per 0.29/0.5 mm thick aerogel). To yield monolithic silica aerogel for window applications Union College developed and patented a rapid supercritical extraction (RSCE) method (Bhuiya *et al.*, 2016), using a hydraulic hot press, the 30-ton Tetrahedron MTP-14 press, with an innovative mold which allows to vary the thicknesses. The specimens made for this work have dimensions 13 x 12.5 x 0.29 cm.

Table 1 - Precursor recipes for samples fabrication

Sample	TMOS [g]	MeOH [g]	DI Water [g]	NH_4OH [µL]
Recipe A-1	26.4	66.1	10.9	816
Recipe B-2	26.4	57.1	10.9	2250

Assembly of glazing system prototypes

In order to assess the improvement of a high-performance commercial double glazing (DGU) as a consequence of the insertion of monolithic aerogel into the cavity, optical and color rendering tests were performed on the samples described in Table 2. The insulating glass samples were assembled using a 9 mm thick aluminum channel fixed with double-sided adhesive tape (Fig. 1).

Table 2 - Analysed samples

Sample	Description	Thickness [mm]
Aer	monolithic aerogel (2.9 mm)	2.9
low-e	low-e glass layer (4 mm)	4
float	float glass layer (4 mm)	4
DGU low-e	float glass layer (4 mm) air layer (9 mm) low-e glass layer (4 mm)	17
DGU Aer low-e	float glass layer (4 mm) air layer (6 mm) monolithic aerogel (2.9 mm) low-e glass layer (4 mm)	17

Figure 1 - Double glazing units prototypes: DGU low-e (left), DGU Aer low-e (right)

Optical analysis

The optical performance, in particular in terms of transmission and spectral reflection, of the monolithic aerogel was measured using the Spectrophotometer Solidspec-3700 (Fig. 1) in the 250 - 2500 nm wavelength range, available at the Laboratory of Environmental Control, Engineering Department at University of Perugia. The results obtained were post-processed according to the reference technical standard (EN 410 (CEN, 2011))and the most significant parameters were estimated: the light transmittance factor (τ_v), the direct solar transmittance factor (τ_e), the light reflectance factor (ρ_v), and the direct solar reflectance factor (ρ_e).

Color rendering evaluation

The color rendering of glazing systems was evaluated following a new methodology, which introduces the evaluation of an optimized Colour Rendering Index ($R_{a,p}$) applying the standard CIE procedure (CEN, 2011) to the experimental data related to the CIE Lab chromatic coordinates, instead of resort to material's transmission spectra as for the general index currently in use (R_a). Another difference compared to the traditional calculation procedure of R_a index for transparent components, is that the color rendering is not evaluated for an object lit by the light transmitted through the element, but refers to an object observed through the transparent material. At the geometric level, the difference lies in the reciprocal position of the source, the observer and the observed object, considering the transparent element as a separating surface, with respect to which it is possible to identify two sides.

Colorimetric analyses were carried out by means of an Illuminator (Fig. 2) and a Minolta Chroma Meter CR-200 available at the Industrial Engineering Design and Methods group of the Perugia Department of Engineering. The illuminator consists of a fiberglass hemisphere that reflects the white LED light on the inspection area beneath it (illumination level approximately 460 lux), thus simulating the reference illuminant D_{65}. A digital camera is anchored by a rotating support to a hole on the top of the illuminator and it is configured for return uncompressed 24-bit RGB images. Camera management, images capture and transfer to a PC in JPEG format are handled by uEye Cockpit tool. The Chroma Meter is a portable tristimulus colorimeter, composed of a viewfinder with a reflex lens, which allows precise targeting on the image to be investigated for measuring and recording the Yxy coordinates, namely quantitative analysis. As a reference for color detection, the ColorChecker-24 and ColorChecker-140 were used, mosaics of 24 and 140 color patches respectively. The former enables to investigate a wide range of tones and how the presence of transparent material or glass system affects the perception of color, the latter to evaluate the color rendering index. For each patch of the ColorChecker-24 with and without the samples was taken a picture by means of the Illuminator acquisition system; then the RGB coordinates and the corresponding histograms were derived by Photoshop and compared. xyY coordinates of each patch without the sample were measured by means of Chroma Meter, setting Illuminant D_{65}, and converted to CIE Lab coordinates with a double transformation. In the presence of the sample is not possible to do likewise for determining CIE Lab coordinates, because the pointer of the Chroma Meter must be in direct contact with the colour surface; an alternative procedure was therefore adopted. By implementing via Matlab a function based on RGB CIE Lab coordinates of the 24 patches without the aerogel, 12 unknown coefficients were determined, from which a linear model was implemented, to convert for patches with aerogel RGB coordinates, device-dependent, to CIE Lab coordinates, device independent. The Lab coordinates were then used to evaluate the differences between the individual coordinates of the reference color observed directly and through the monolithic aerogel sample or the glazing system prototype, and to assess the values of the chromatic divergence ΔE in the different cases:

$$\Delta E = \sqrt{(L_{AER} - L)^2 + (a_{AER} - a)^2 + (b_{AER} - b)^2} \quad (1)$$

At last, the ColorChecker-140 was used to calculate the optimized Colour Rendering Index ($R_{a,p}$) according to EN 410 (CEN, 2011). Among the 140 patches, eight test colors were selected, which correspond to neutral pastel light colours with low saturation. Following the methodology exposed above, for each test color the distortion was quantified through Eq. 1 as the Euclidean distance between the two positions in the CIE Lab CIE Lab chromaticity space, ΔE_i, with $i = 1, \dots, 8$.
On the basis of these values of the chromatic differences ΔE_i, it was possible to compute the special Colour Rendering Indices $R_{i,p}$ for each colour sample through the equation:

$$R_{i,p} = 100 - 4{,}6\ \Delta E_i \quad (2)$$

The general Color Rendering Index $R_{a,p}$ was obtained as the average of the special Color Rendering Indices R_i of the 8 patches. The $R_{a,p}$ values obtained for each sample by means of the new proposed methodology were finally compared with the R_a calculated by the procedure of the Standard which exploits the transmission spectra (CEN, 2011).

Figure 2 - Sample positioning inside the Solidspec-3700 for transmission measurements (left); Colorimetric characterization (right)

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Results and discussion

Optical analysis

The single low-emissive glass (low-e) and the low-emissive DGU (DGU low-e) were analyzed in transmission from the inside to the outside, that is, by placing as the first layer crossed by the radiation the glass with low-emissive treatment. The reflection measurements were conducted in the opposite direction, namely low-e glass as the last layer. The glass panes have high values in the visible range (0.90 for float, which is reduced to 0.88 for Low-e sample) (Fig. 3). The float glass has an almost constant trend, followed by a reduction of transmission in the near infrared up to about 1600 nm, whereas the low-e glass (looking from the inside outwards) shows a significant reduction as soon as left the visible field.
DGU Low-e (looking from the inside outwards) has the same trend as the simple low-e, with further reduction due to the float layer.
By inserting the aerogel in the cavity, out from the visible field the trend is exactly overlapping that of a float plus low-e double glazing. The only worsening element of the performance is given by the further lowering of the transmission peak in the visible range, the maximum transmission coefficient decreases from 0.78 at λ = 570 nm per DGU Low-e to 0.75 at λ =575 nm per Aer Low-e.

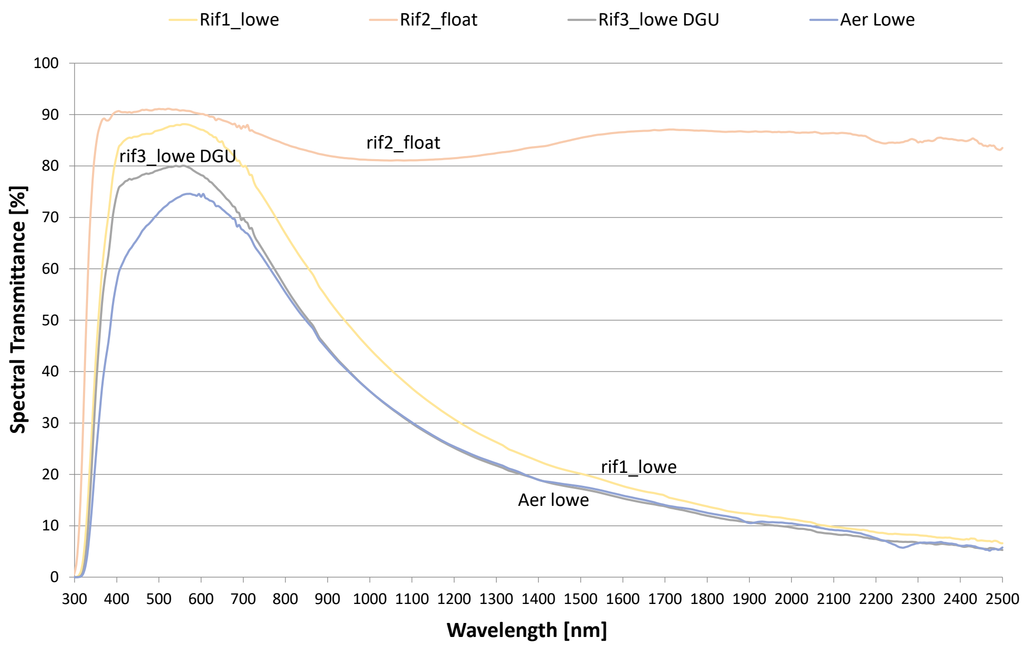

Figure 3 – Spectral transmittance, overall samples comparison

In the visible field the shape of the reflective pattern of the float panel, low-e panel and low-e DGU system samples have comparable trends (Fig. 4). The high reflectance in the first visible wavelengths of the DGU Aer low-e peak at λ= 355 nm, where $r_{max} \approx 0.22$, is due to the behavior of the aerogel. In the near infrared the two curves overlap, in contrast with the difference noted by Moretti et al. (2019) introducing granular aerogel in the cavity of DGU float.
The float pane also in the case of reflectance, as for the transmittance, shows a trend almost constant around 0.09. For λ higher than 700 nm, the low-e glass reflects as expected, and this leads to an increase in the reflectance of the DGU with a low emissive glass.
Aerogel reduces the reflective benefit of low-e by glass absorbing some of the radiation (visible absorption peaks).

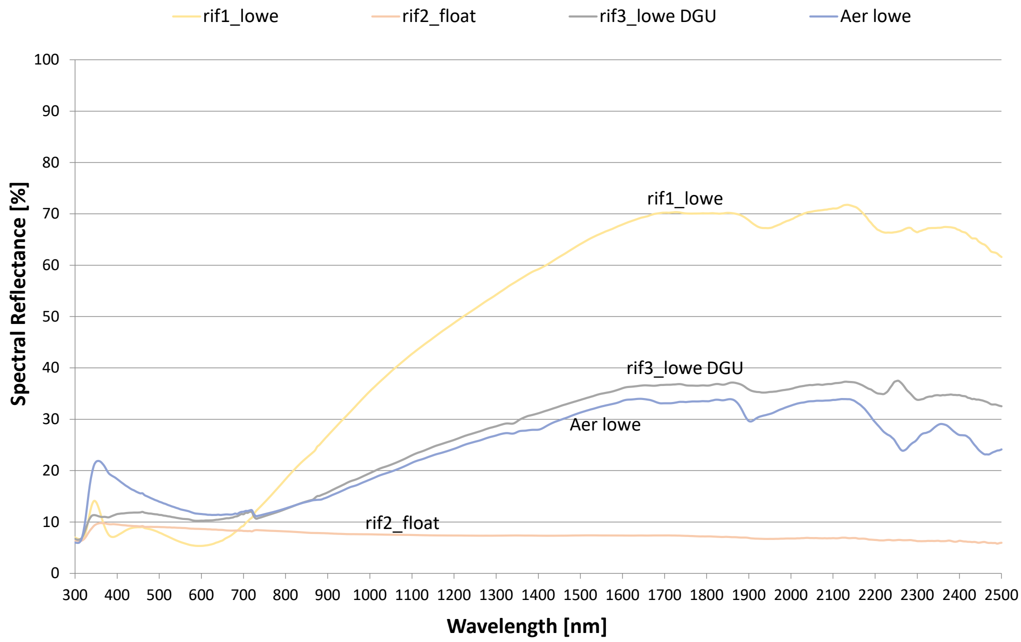

Figure 4 – Spectral reflectance, overall samples comparison

Table 4 - Optical parameters calculated for the samples

Sample	τ_v	τ_e	ρ_v	ρ_e	α_v	α_e
rif1_low-e	0.87	0.64	0.06	0.22	0.07	0.14
rif2_float	0.91	0.86	0.09	0.08	0	0.06
rif3_DGU low-e	0.79	0.56	0.14	0.13	0.07	0.31
DGU Aer low-e	0.73	0.52	0.13	0.17	0.14	0.31

The direct solar and light transmission and reflection factors calculated on the basis of the measured spectral data according to EN 410 are reported in Table 4.
Float glass has higher visible transmission, comparable reflections coefficients and absorption slightly higher in solar.
The low-e has greater transmission in the visible field (much reduced in the solar for its operation principle), greater reflection and absorption in the solar field.
DGU low-e system has both visible and solar transmission coefficients lower than those of the analyzed simple glass types, with τ_e 0.56, significantly lower than τ_v, equal to 0.79, due to the effect of the low-e layer. For this system light and solar reflection are comparable (about 0.14).
The values in Table 4 show that the insertion of the aerogel layer in a DGU having a float layer and the other low-e, reduces τ_v by 8% from 0.79 to 0.73, whilst the solar transmittance factor undergo a lower reduction, of 7%. For the proposed glass system, ρ_v results reduced compared to DGU low-e with air in the cavity. DGU Aer Low-e ρ_e results in an increase in the reflection coefficient in the solar field by 30% compared to common low-e.

Color rendering evaluation

The effects of reducing the thickness of the monolithic aerogel by 86% are reported in terms of ΔE in Figure 5. The maximum ΔE for monolithic aerogel 1.27 cm thick occurs for the colors C3 (59.12), B6 (54.90) and B1 (54.63), on yellow-red tones with low B coordinate in the RGB system. Significant variations were also found in general for dark colors; ΔE for black is 39.97. The minimum were obtained for D2 (10.16), C6 (13.53) and A6 (12.70), very light and with G and B coordinates prevailing. For the mentioned tiles, the RGB are respectively 197, 255, 233; 55, 150, 218; 111, 229, 194. The reduction in thickness results in a decreasing of the average color shift from 33.99 to 12.65. ΔE appears considerably lowered for the colors B1, B6 and C4, which were previously the most penalized. For the 0.29 cm thick aerogel, the colors which suffer the greatest distortions are D1, D2, D3, whitish or neutrals, for which ΔE increases compared to that of the 1.27 cm sample. On these, the blue shade of the material is responsible of an excellent adherence to the bluish colors as A6, A3 and C6, for which the ΔE are respectively 2.7, 6.7 and 7.2. In this case a variation in the thickness of the aerogel does not correspond to significant differences in ΔE. Despite being in blue tones, remarkable ΔE were shown by patches "blue", C1, and "purplish blue", B2, because of the low coordinates R and G, which determine their dark appearance. For the A2 “light skin” patch, the presence of the aerogel is almost irrelevant (E=3.35). The shift of black is finally reduced by 25.7.

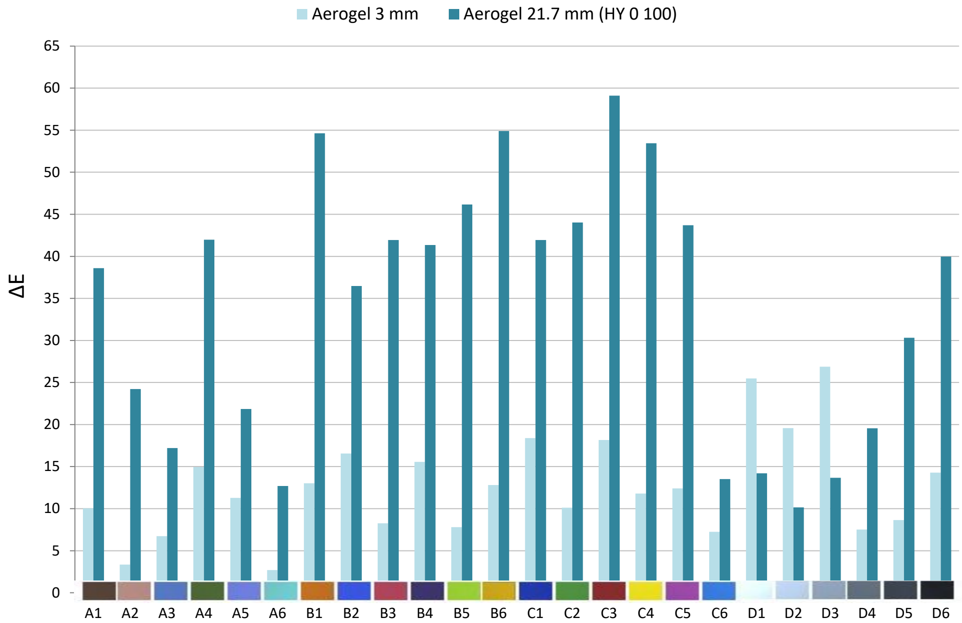

Figure 5 - Comparison of color shift between aerogel samples of different thickness

Colorimetric analyses were carried out on double glazing systems (Table 3) both with air gap and after the insertion of a layer of 0.29 cm of aerogel in the interspace in adherence to the low emissive layer, evaluating the vision from both sides (Figure 6). In the absence of aerogel the colors which seen through DGU undergo the greatest variations are dark, C3, and with blue coordinate prevailing on the others, C5, C1, in addition to those having simultaneously high R and G coordinates (yellow tones) such as B6 and B1. Colors subjected to minor variations are A6, D4, C6, light and with simultaneously high G and B coordinates. In general the greatest distortion of colors is encountered looking from the low-e side; the exceptions are B5, B6, A2, characterized by a high percentage of the R coordinate, and C2, moved away from the original tone by the float glass. Also whites (D1 and D2) appear more faithful to the original color when viewed from the low-e side.Average ΔE of the standard DGU is 21.7, lower than that of the 1.27 cm aerogel monolith, but higher than that of the thin sample. By inserting the aerogel into the cavity such deviation further increases by 3.5. Exceptions are represented by “White” (D1), whose vision is overall improved after the insertion of aerogel, and “Neutral 6.5” (D3) for which it improves the vision from low-e side. In both cases the black is quite distorted, with average color shift values equal to 24.9 and 28.7 respectively for DGU low-e and DGU aer low-e. Introduction of the aerogel layer worsens C4 "yellow", B1 "orange" and B5 "yellow green", while it is responsible for minor deviations for A6, as seen in the analysis of the plain aerogel. When seen from the float side, colors are always more reliable than seen from the opposite side, with the exception of the colors around the white (D1, D2, D3), for which the deviation caused by the aerogel in favor of blue shades is contrasted by the reflection of the low emissive layer.

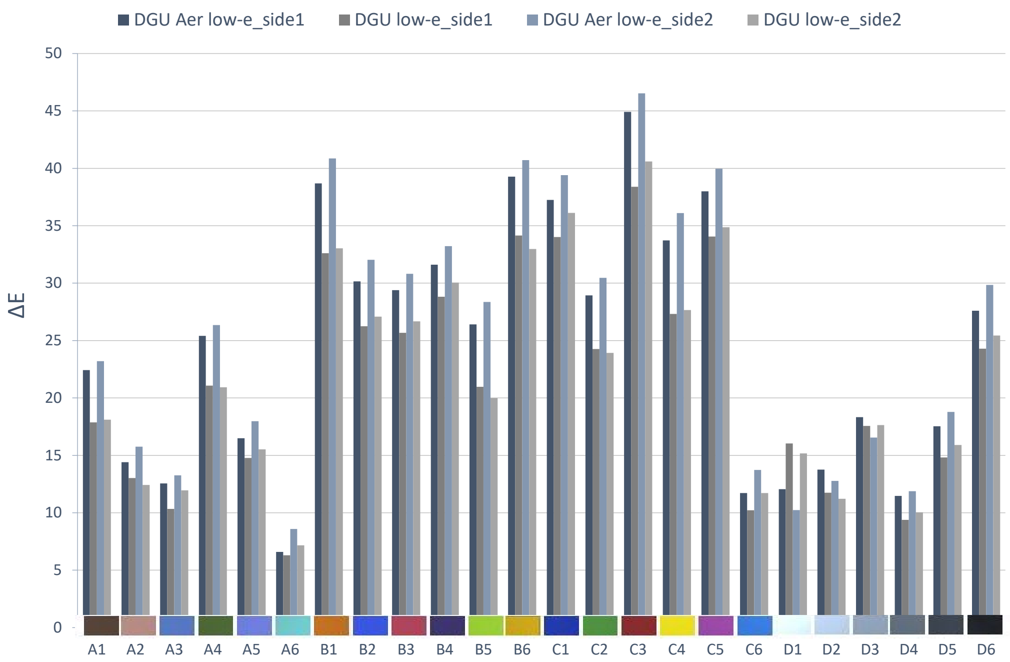

Figure 6 - Front-back DGU and DGU with aerogel

The proposed general Colour Rendering Index ($R_{a,p}$) was calculated according to the procedure presented in "Methodology" Section, on the basis of the distortion ΔE_i of 8 or 14 reference colors selected from the 140 patches of the ColorChecker-140. In Tab. 5 the estimated $R_{a,p}$ of the samples is reported, along with the general color rendering index R_a calculated by applying the standard CIE procedure, in compliance with EN 410 (CEN, 2011). $R_{a,p}$ of DGU low-e samples is lower than the one of DGU Aer low-e, showing an increasing of the color performance when introducing a thin layer of aerogel in the gap (from 84 to 87-88). Average ΔE is in fact lower in the case with aerogel (the only colors that worsens are B3, B8 and I2). Considering 14 patches, $R_{a,p}$ for both samples are lower than those obtained with 8 colours; this is due to an increase in average ΔE, in particular for DGU low-e, and as a result the difference between $R_{a,p}$ with and without aerogel increases. Indeed for only one of the four added patches ΔE is worse in the presence of aerogel (B8). This is meaningful of the weight of the colors'choice on the final values of the color rendering index. When compared to data obtained from the methodology of the EN 410, lower values are obtained for $R_{a,p}$; anyway the EN 410 does not seem to be able to detect the influence of the insertion of the thin aerogel layer (Ra is equal to 98 for both the DGU samples, with and without aerogel).

Table 5 - General Color Rendering Index: comparison between the standard and the new methodology

Sample	R_a		
	New methodology (8 patches)	**New methodology (14 patches)**	**EN 410**
rif3_DGU low-e	85	84	98
DGU Aer low-e	88	87	98

Conclusions

Transparent surfaces of buildings significantly impact perceived color and brightness of a lit object, having a great effect on indoor visual comfort. At once they are in charge of considerable energy consumptions. Aerogel in monolithic form has excellent thermal, acoustic and optical properties, so its use as a stratum of multi-layer glazing systems is promising to solve gaps that make glass

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surfaces a weak element of the building envelope.Although RSCE production method is scalable, due to the extreme brittleness of thin aerogel it is not easy to fabricate monoliths of the size required for typical glazing units, reason that hinders the market spread of these fenestrations. With the aim of improve optical properties and color rendering of high-performance glazing systems with a monolithic silica aerogel layer, the present work focused on how the thickness reduction of the aerogel pane enhahces its color rendering, and therefore on how the insertion of this thin monolith into the cavity affects a low-e double glazing unit (DGU) in terms of optical properties and color rendering. The same context was exploited to sensitivity assessment of a new qualitative methodology for color rendering calculation, about the performance of transparent layers and systems. Reducing the thickness of the monoliths by 86% means that average ΔE decreases from 33.99 to 12.65. ΔE appears considerably lowered for colors on yellow-red tones with low B coordinate, most penalized by thick aerogel; instead it increases for whitish or neutrals, affected by blue shade of the material. 0.29 cm-thick aerogel shows the lowest ΔE for bluish colors (in 2.7-7.2 range), for which thickness variation does not correspond to significant differences in ΔE. Remarkable ΔE were shown by thin aerogel for dark patches, due to low coordinates R and G, despite in blue tones; shift for black is reduced by 25.7. Small prototypes of DGU were tested. Incorporate a thin silica aerogel layer in part of the interspace between glass layers entails a lowering of the transmission peak in the visible range by 3 percentage points and average ΔE of the standard DGU increases by 3.5 from 21.7. Without aerogel major variations occur for dark colors and with blue coordinate prevailing on the others or with simultaneously high R and G coordinates (yellow tones). The introduction of aerogel improves vision for “White”, and “Neutral 6.5”. In both cases black is quite distorted.Applying the new procedure for R_a determination, a good quality of the vision through the glazing aerogel ($R_{a,p}$ =88) was obtained. Reduction of $R_{a,p}$ as the number of considered patches increases, together with comparison of the average ΔE obtained with color checkers 24 and 140, are representative of conditioning of the choice of test color samples on color rendering indexes.

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4. Color and Physiology

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The gray side of Ishihara bubbles

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Abstract
In this paper, we present a novel experiment on a modified Ishihara-like series of plates for color deficiency screening. This is a further experiment in the direction of exploring the spatial modifications of this classic test so to explore the role of visual spatial arrangement in the assessment of normal and color deficient observers. In this work, we present the test setup with some preliminary results on normal color vision observers.

Keywords: color deficiency, color blindness, Ishihara plates.

Introduction

The Ishihara test plates are designed to offer a rapid and usable instrument to diagnose color deficiency. The original test, as well as other PIP (Pseudo-Isochromatic Plates), consist of a set of plates, composed by a circle filled with colored dots of different colors and sizes. Modern Ishihara color plates are combined with a manual for the interpretation of the results (GIMA, 2021), which makes this test very simple.

The Ishihara test is widely accepted to assess congenital red–green deficiencies (protanopia, deuteranopia, protanomaly and deuteranomaly), but cannot be used screen tritanopia, which is a very rare condition (Rodriguez-Carmona, *et al*., 2021). Main advantage of this test is that it is not only highly usable but also presents a high reliability in detecting color vision deficiencies, even if this method is not clinically appropriate to classify the type of defect (Barbur, *et al*., 2021).

Ishihara plates and PIP are designed starting from the transformation of different type of color deficiency in chromatic coordinates in CIExy space, considering that each one of the color deficiency types is linked to an anomaly in the *photopsins* in L, M or S cones cells. Considering the CIE chromaticity diagram, color deficiency types can be graphically represented by their relative *confusion lines* (see Fig. 1). Here, the colors in PIP are aligned on the confusion lines, in order to be visible just to trichromats observers and to be "confused" (i.e., indistinguishable) by color deficient

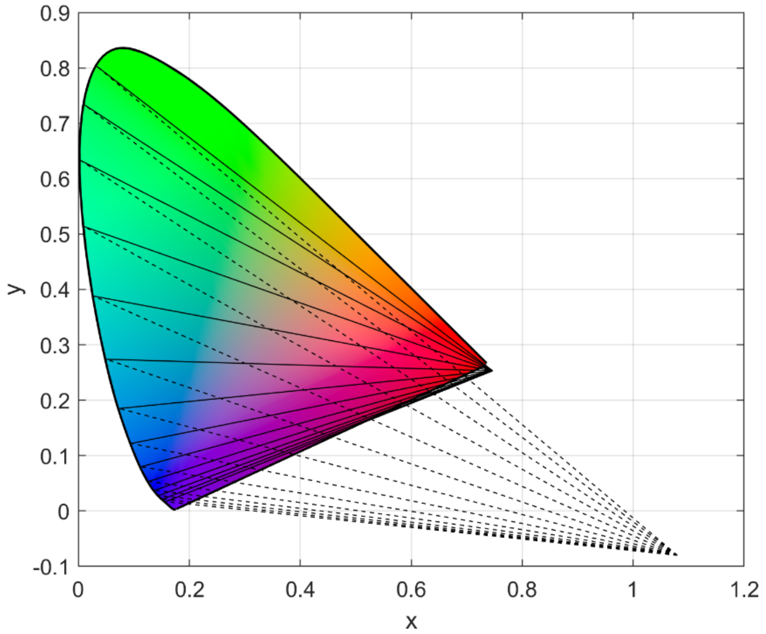

Fig. 1 - CIE chromaticity diagram, with confusion lines of protanopia (solid lines), deuteranopia (dashed lines)

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observers. Following this idea, many different test images can be generated and today, these tests can be performed on printed papers, but also on digital versions (Seshadri, *et al.*, 2005), (Sorkin, *et al*., 2016). The clinical Ishihara version, as well as other Ishihara-based test (on paper and in digital) presents a white background and some millimeters/pixels of space among colored points. This standard arrangement is designed to assess color deficiency at retinal level, thus employing confusion lines derived from transformations of specific characteristics of L, M and S cones. However, several studies in biology, neuroscience and ophthalmology confirm that color vision is way more complex, and it is not limited to retinal transduction. Final color sensation depends also by the brain signal processing which is mainly spatial (McCann, 2017). This effect has been demonstrated by different experiments, some of these also applied to color deficiencies, showing the increment in the correcting rate by color deficient observers in Ishihara-based charts with larger dots (i.e., reducing or totally eliminating the space among dots) (Rizzi, et al., 2014) (Eschbach & Nussbaum, 2021).

These observations underline the importance of defining new approaches in describing color deficiencies and in developing related aids and tests, because of the strong scene dependency of color vision also for deficient observers.

This work starts from the experiment presented in (Eschbach & Nussbaum, 2022), where authors found a surprising improvement in distinguish colors on confusion lines for color deficient observers by changing the background color of PIP tests to neutral gray levels. From these finding we developed the same experiment applied on color normal observers, to assess if a different gray background level will also change recognition rate/time for color normal observers, further evidencing a spatial behavior in color vision system.

Related works

For the visual test, we used pseudo-isochromatic charts as described in (Eschbach & Nussbaum, 2022), obtained combining colors located on CIExy confusion lines. In Fig. 2 a cropped window of the used charts is shown.

In this experiment we used charts which have been tested in a larger experiment for color-normal and color-deficient people (Eschbach & Nussbaum, 2021). The PIP charts are composed by ten numerals (from 0 to 9) and colors from 10 confusion lines. From this overall set, 34 charts have been used to form the base set. This base set had a roughly 97% recognition rate for color-normal observers, keeping in mind that observers sometimes hit the wrong key on the keyboard by accident, while color deficient observers had a recognition rate of roughly 43%. For that reason, we consider the charts we created and used to be a good implementation of pseudo-isochromatic charts. In a previous version of this experiment (Eschbach & Nussbaum, 2022) we changed the white background of the charts to different gray levels in order to examine the response of color deficient

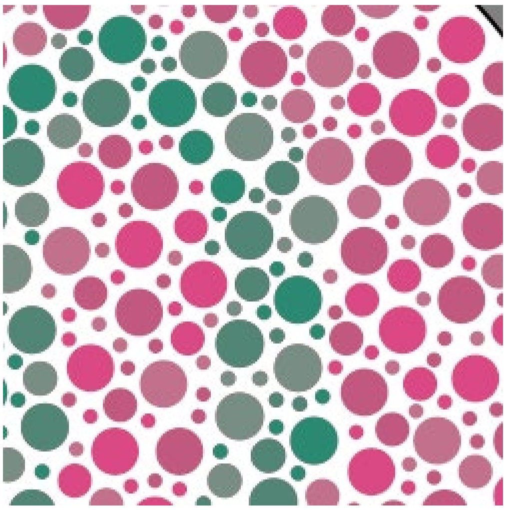

Fig. 2 – Example of PIP chart.

observers. For this, we changed the white RGB background (255) to 4 additional values 0, 64, 128 and 192. It is important to note that the RGB values of the colored dots have not been changed. Their chromaticity values remained constant, their sizes and positions remained constant, and their spatial relationship remained constant. Considering Fig. 2, only the white areas have been replaced by grays and blacks. This leads to charts, where the gray-level contrast between background and colored dots changes, with the two end values [0, 255] having maximum contrast. In this preliminary experiment we recruited a small number of color deficient people (N= 6) and to perform the test. The experimental data, however, showed that the gray background actually improved the recognition rate (see Table 1).

Background RGB value	0	64	128	192	255
Recognition Rate (rounded)	54%	67%	54%	32%	17%

Tab.1 – Recognition rate of color deficient observers from (Eschbach & Nussbaum, 2021).

Experiment

The results presented in the previous section poses an immediate question color normal observer, which can be phrased as:

If there is a clear mechanism or channel for a color deficient observer, does this mechanism also exist for a color normal observer, although at a lower level?

In other words: a person with good color discrimination will rely on his/her capability without the need to incorporate a different mechanism. In that manner, the additional channel would be "masked" by the stronger signal from the color discrimination channel. A color deficient observer would not have that masking and thus a different mechanism might be exposed. A secondary examination of color normal then might be used to verify if that mechanism is available, but "hidden" as a very low signal superimposed on a strong signal.

For this reason, we re-ran the experiment of (Eschbach & Nussbaum, 2022) on a set of color normal observers. The only modification to the analysis was the incorporation of response time. For color deficient the response time was heavily influenced by a few charts were the observers had the feeling they "might" see something. For normal color observers, we did not expect a variation in recognition rate and expected to see a variation in response time with lower response time indicating an easier visibility.

We performed the experiment on 11 color normal observers with a total of 881 charts, with the standard pseudo-isochromatic chart having a background level of 225. The results are reported in Tab. 2.

Background level	0	64	128	192	255
#charts	127	151	132	141	165

Tab.2 – Number of charts displayed for every background gray-level (e.g., the chart with background at 128 has been displayed 132 times).

The reason that we had different usage numbers for the different background levels is the random number generator used in PsychoPy (PsychoPy, 2022). The only chart that had a deterministic number was the standard white background chart (255) since we wanted to make sure that all observers would be qualified as color normal. This can also be seen in the accumulated data in Tab. 3.

Background	0	64	128	192	255
Recognition Rate	96.99%	97.52%	99.30%	99.24%	96.97%

Tab.3 – Recognition rate of color normal observers.

Comparing Tab. 1 from (Eschbach & Nussbaum, 2022) and Tab. 3, we can observe that the "trend" for color normal observers mirrors the one of color deficient observers at a much smaller scale. For a color deficient, the change was from 17% to 67%, for a color normal it was from 96.97% to

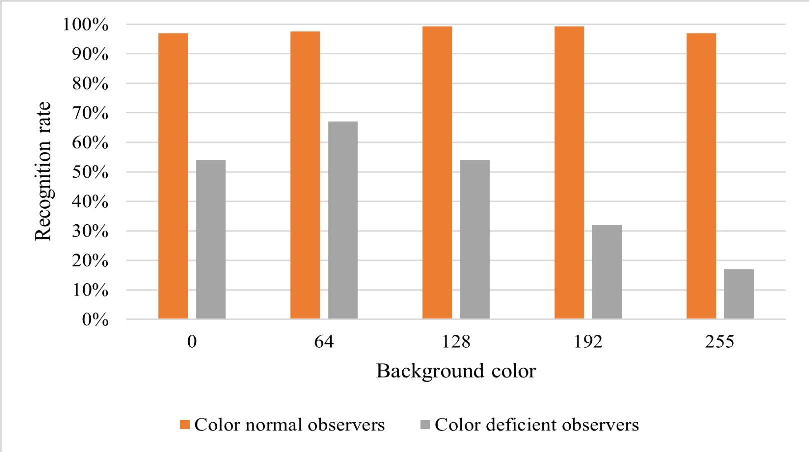

Fig. 3 – Recognition rate of color normal and color deficient observers using different gray-level background values.

99.30%. For both the observers groups the end points of the background level were performing worse than the center levels (roughly). When looking at the data embedded as a Fig.3, the trend becomes more obvious.

Considering Fig. 3 values is understandable that such a small effect can easily be asked by the experimental surroundings.

Additionally to the recognition rate, we also examined the color normal observers response time.

Background	0	64	128	192	255
Response Time (in seconds)	1.710	1.657	1.587	1.859	2.449

Tab.4 – Color normal observers response time.

Fig. 4 shows a clear decrease in response time for the mid-gray values. Again the extreme background levels have a higher response time than the middle terms, mirroring the recognition rate, under the assumption that recognition rate and response time are inversely correlated, meaning a “harder to recognize” (thus more errors) leads to a higher response time (harder to recognize).

Conclusions

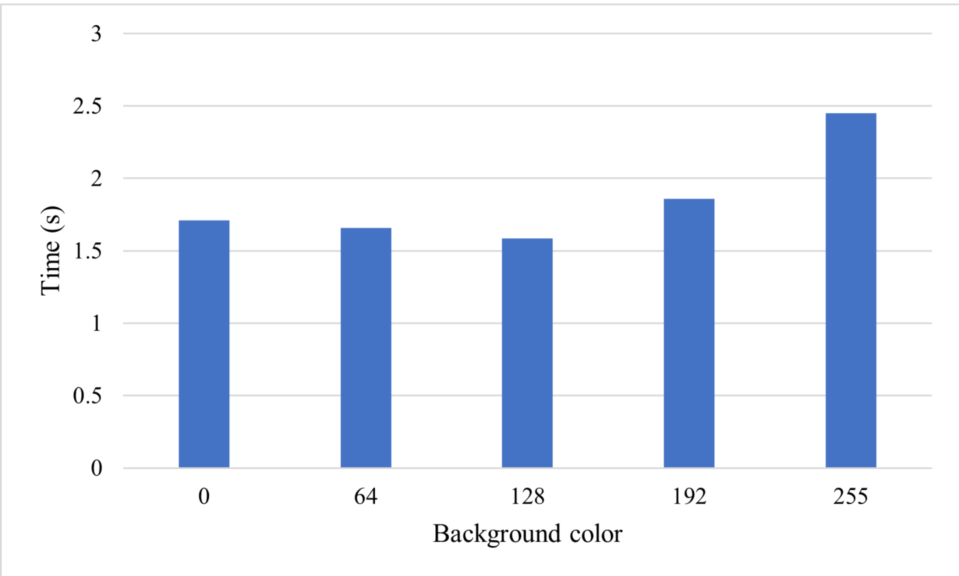

Fig. 4 – Response time of color normal observers.

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Color vision and color vision deficiency is commonly simplified considering vision just at retinal level, without considering the higher-level signal elaboration, which is mainly spatial. This approximation includes also color vision screening tests, like pseudo-isochromatic plates.
In this work we explore the introduction of spatial modifications on classis PIP tests, to determine if changes in the plates background can influence color vision in normal and color deficient observers.
A previous experiment published in the literature revealed that changes in PIP tables background could effectively influence the recognition rate in color deficient observers, from 17% (with white background) to 67% with RGB 64 gray and 54% with RGB 128 gray. In this study we have tested some color normal observers revealing the same trend (96.97% of recognition rate with white background vs 97.52% with RGB 64 gray and 99.30% with RGB 128 gray).
These results shows that color discrimination mechanisms rely on spatial behaviors not only for color deficient people, but also in color normal viewers, increasing not only the recognition rate, but also lowering the recognition time.
In future works this phenomenon should be furtherly investigated, and those findings should be considered also in methods to develop innovative color vision aids and tests.

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Can "blue blocking" eye glasses be clinically really effective?

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Abstract

The technologic knowledge is, that about 30-50 % of the certain blue light wavelengths passing glasses are reduced with blue blocking glasses. If the clinical effect is to expected to reduce the amount of blue light, the effect is not enough to reduce the potential hazardeous effect of blue light wavelenths , because in daylight the light amount is about 100.000 lux. Indoors it is mostly only 100-500 lux when iluminated enough. As second ophthalmological knowledge there is no scientifically proven hazardeous effect of the blue light wavelengths. In daylight conditions the effect of all wavelengths including blue light is so high, that a reduction of 30 % is not effective enough. Additionally there should be scientifically significant evidence for every wavelength. There is no scientifically significant evidence for prescribing blue blocking eye glasses.

Keywords: blue light blocking, eye glasses, prescription, clinical effectivity

Introduction

In the last decades there have been many publications about blue hazard to the retina, which are combined with suggestion of the use of optical blue-blocking filters as eyeglasses or intraocular lenses. In the last years there new acknowledgements about the effect of the blue light on retina. This study reviews the state-of-art in blue light effect on the retina.

To understand the amount of light coming to the eye, the comparison should be made between the illumination levels outdoors and indoors at the screens, where blue light blocking glasses are suggested.

Illumination from screens and outdoor

Desktop computers:	0.5 - 37.8 lux.
Laptop computers:	1.7 - 14.5 lux.
Tablets:	0.7 - 5.9 lux.
Smartphones:	0.6 - 2.1 lux.

List 1. Illumination levels at screens which are viewed by humans

Sunny sky:	10.000-100.000 lux.
Shadow at the sunny sky:	2.000 lux.
Cloudy sky	1.500-2.000 lux.

List 2. Illumination levels outdoor at day viewed by humans

Illumination indoors	100-500 lux.

List 2. Illumination levels outdoor at day viewed by humans

If the effect of light on the retina is cumulative, there is 1.000-10.000 times more exposure difference between smartphones and daylight. (1 minute daylight equals about 16-160 hours exposure to smartphone screens). Exposure difference between laptop / desktop screens and daylight is 70 to 25 times. (1 minute daylight equals about 1-10 hours exposure to laptop screens and 2-20 hours of desktop screens).

The blue blocking effect of eyeglass filters with 20-60 % may be neglected in daylight.

Scientific data about blue light effects on the retina
Shang et al (2014) showed in rats that exposure to blue light wavelenghts can damage the rat retina. There have been other studies with similar findings at that years. All this research has been made on rodents.
Tao et al (2019) found the changes (fragmentation) of cell mitochondria in rodents as a possible cause for blue light damage to the retina.

In the study of Theruveethi et al (2022) the influence of blue light exposure using light-emitting diodes on retinal histology and visual cortex neurons in rodents were shown. They predicted that their study showed that prolonged exposure to high levels of blue light pose a significant hazard to the visual system resulting in damage to the retina with the associated remodeling of visual cortex neurons. Blue blocking lenses may offer moderate protection against exposure to high levels of blue light. This study had been made on rodents also.

In the literature review study of Ouyang et al (2020) it has been stated that blue light, with relatively high energy, can cause irreversible photochemical damage to eye tissue. Excessive exposure of the eye to blue light tends to cause a series of alterations, such as oxidative stress, mitochondrial apoptosis, inflammatory apoptosis, mitochondrial apoptosis and DNA damage, resulting in the development of dry eye disease, glaucoma, and keratitis. Accordingly, physical protection, chemical and pharmaceutical protective measures, gene therapy, and other methods are widely used in the clinical treatment of blue light hazard.

Blue-light filtering spectacle lenses were found optically effective in reducing the blur light in the study of Leung et al (2016).

In the study of O`Hagan et al (2016) is had been stated that continuous viewing of the blue sky may have similar effects as lamps, computer screens, mobile devices and smartphones. Under even extreme long-term viewing conditions, none of the assessed sources suggested cause for concern for public health.

In the study of Dain (2020) fluorescent lamps were shown essentially to have the same proportions of blue light and LEDs do not represent a special case, given the same correlated colour temperature. Blue-blocking lenses are no more needed with LED sources than with other screen illumination methods or with fluorescent lighting. There is no evidence base on which to recommend blue-blocking lenses for indoor applications.

Jaadane et al (2020) showed that GaN-onGaN diodes (which are used in the studies) are more toxic than conventional LED for the rat neural retina and the rat retinal pigment epithelium indicating that the BLH (blue light hazard) weighting is not adapted to this type of diodes. One of the reasons of this increased toxicity is the effects of shorter wavelengths on mitochondria polarization. They showed that the threshold of phototoxic retinal dose in the rat (fxed at 11J/cm2, BLH weighted) is overestimated, suggesting that the values used for regulations, calculated in primates using the same methods than in rats, should be revised.

In the study of Mainster et al (2022) the purpose have been that the blue light hazard is the experimental finding that blue light is highly toxic to the retina (photic retinopathy), in brief abnormally intense exposures, including sungazing or vitreoretinal endoillumination. They stated that this term has been misused commercially to suggest, falsely, that ambient environmental light exposure causes phototoxicity to the retina, leading to age-related macular degeneration (AMD). They analyzied clinical, epidemiologic, and biophysical data regarding blue-filtering optical chromophores. Their results showed that large epidemiologic studies show that blue-blocking intraocular lenses (IOLs) do not decrease AMD risk or progression. They stated also that the blue-filtering lenses cannot reduce disability glare because image and glare illumination are decreased in

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the same proportion. Blue light essential for optimal rod and retinal ganglion photoreception is decreased by progressive age-related crystalline lens yellowing, pupillary miosis, and rod and retinal ganglion photoreceptor degeneration. They showed also that healthful daily environmental blue light exposure decreases in older adults, especially women. Blue light is important in dim environments where inadequate illumination increases risk of falls and associated morbidities. They concluded that the blue light hazard is misused as a marketing stratagem to alarm people into using spectacles and IOLs that restrict blue light. Blue light loss is permanent for pseudophakes with blue-blocking IOLs. Blue light hazard misrepresentation flourishes despite absence of proof that environmental light exposure or cataract surgery causes AMD or that IOL chromophores provide clinical protection. Blue-filtering chromophores suppress blue light critical for good mental and physical health and for optimal scotopic and mesopic vision.

Conclusions

Scientific medical state of art of the blue light effect on the retina is, that blue light exposure causes no significant damage on the retina. So medically blue blocking filters aren´t recommended medically.

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Online games for colour deficiency data collection

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Abstract

Trying to investigate the role of edges in the color perception of color vision deficient people requires complex unstandardized setups, possibly leading to longer and more challenging tests. Besides the fact that only less than a tenth of the western population shows some form of color blindness, adding inherent complexity to test setups may likely worsen the scenario and further reduce the availability of test subjects. A possible solution might come from the development of web-based tests, which on the one hand makes it easier for a subject to be enrolled in a study, on the other introduces variability in the form of different devices, environmental and viewing conditions. Not being able to directly monitor a subject also makes it impossible to evaluate its attention and motivation, which likely have a role in the accuracy of the responses given.
In this study, we are investigating the usage of a specifically designed web-based game as a source for larger amounts of data related to color perception; the idea is to exploit the potential of games to become viral and collect large amounts of data with little effort while at the same time addressing variability by means of averaging the outcomes over a large set of test subjects. Developing simple and engaging games might also solve the issue of low motivation and attention, giving to the test subject a reward in the form of entertainment and progress in the game.

Keywords: color deficiency, color blindness, color perception.

Introduction

Color vision deficiency is described as an impairment of the ability to distinguish some colors according to the type of vision defect. This issue has a higher incidence in males (about 8.8%) than in females (about 0. 4%) (Birch, 2012; Hunt and Carvalho, 2016). Screenings and diagnosis of the type and severity of a color vision deficiency can be of great help for the individual, especially in scholarly or young age, when very often the inability to distinguish color could cause discomfort and frustration. Furthermore, a reliable assessment of color vision deficiency can help people in planning their future career or finding creative solutions to overcome their limits.
Color vision deficiency is a genetic or more rarely acquired condition caused by the absence or alteration of one or more cone types in the retina. In general, the total lack of ability to distinguish colors is called monochromacy or color blindness, while the term color deficiency is referred to dichromacy, caused by the absence of one type of cone, and to anomalous trichromacy, caused by the alteration of one cone type. In general, the type of color deficiency depends on the type of cone which is absent or altered: protanopia and protanomaly refer to cones L (red), deuteranopia and deuteranomaly refers to cones M (green) and tritanopia and tritanomaly refer to cones S (blue).
The most common type of test are the Pseudo Isochromatic Plates (PIP), like the Ishihara test. In these tests the observer should identify a colored symbol embedded in a colored background and colors are chosen to be easily distinguished by trichromats since they lay on color deficiency confusion lines (Judd, 1945). The great success of paper and digital versions of these tests relies on their easy applicability, since using a few tables it is possible to assess the presence of color deficiency and have a preliminary screening of the type of defect. Tests like Ishihara plates are widely used in clinics and occupational environments and present a high sensitivity in screening congenital red and green deficiencies, while this test is not suitable to screen tritanopia/tritanomaly (Cole, 2007) (Rodriguez-Carmona *et al.*, 2021).
Another important and diffused family of color vision screening tests are the arrangement tests. In arrangement tests, the observer is required to arrange color samples by similarity in a sequential

color series. Tests from this family, like the FM 100-hue test of the Farnsworth Panel D-15, are very intuitive and easy to administer, but require the observer's patience and concentration, hence they are less suitable for young children. Those tests can be useful to diagnose the type of dichromacy but perform less well to diagnose the anomalous trichromats (Rodriguez-Carmona *et al.*, 2021).
Among other less diffused families of color deficiency diagnosis tests like lantern tests, CAD test or computer-based test, it is mandatory to name the anomaloscope. The anomaloscope is the standard instrument to diagnose color vision defects and classify the defect type. It is an optical instrument, where the observer manipulates stimulus control knobs to match two colored fields in color and brightness. Thanks to this test, it is possible to characterize not only color deficiencies but also anomalous trichromats. Despite its high precision and reliability, the anomaloscope is very difficult to use since it requires an extensive training of the examiners, constant supervision and calibration (National Research Council, 1981). Considering all the specific characteristics of the most used color vision assessment tests, today it could be very hard to obtain a consistent set of data to develop the research on color deficiency or just to raise the awareness of common people to color vision issues. Specific tests can require concentration, cause stress and frustration on the patients because of their clinical nature and be unsuitable for young children or people with behavioral problems.
The development of web-based tests could be a preliminary solution to gamify classical clinical tests and collect large amounts of data to make research and improve the current tests and diagnosis methodologies. Certainly, this solution will never substitute a clinical diagnosis, but it could become an alternative to test in large-scale color vision issues and to make screening in gaming conditions.
Following this idea in this paper we define some tips and tricks to develop an online color vision test based on our experience and we present a first practical example which helped us to test a large number of observers on the role of edges in color vision assessment.

Tips and tricks to develop online tests for color deficiency data collection

The development of online games to test color vision defects has several pros and cons which must be considered before starting to design the game. An online game is surely suitable to reach and enroll a large number of subjects in the study and collect a large amount of data. Anyway, this advantage also presents several challenges because in developing the online game it is important to define and set up a robust data collection system in a manageable format. Furthermore, reaching several different people with an online game entails device variability and different environmental and viewing conditions. This situation can be listed both in pros and cons of this application since the test results could demonstrate the consistency of a theory in different conditions of observation, especially when the same observer played several times and on different devices. On the other hand, this could lead to errors and approximation linked to the different devices' gamuts of used color spaces. In this context, it is clear that in designing the game some precaution can increase the data consistency and reliability and a further solution could be addressing variability by means of averaging the outcomes over a large set of test subjects. The same observations on the device's variability can be applied also to the observer's attention and concentration. Clearly using online games, it is impossible to constantly monitor the subjects' level of involvement, but the test gamification could also create a positive sense of competitiveness and desire to improve, which will surely increase the number of games played and the concentration without stress of the participants.
Another great advantage of designing online games, differently from apps or other traditional computer tests, is that online tests can be customized and modified at any time and the changes appear immediately in the game. This means that it is always possible to fix errors or introduce improvement during the testing or define different test versions to present to the players at different times.
Considering the observation on the general pros and cons of developing online games to assess and test color deficiency it is clear that it remains difficult to diagnose and classify the type of color

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vision defect, as well as the severity. Anyway, if the color vision test is designed to test some specific color vision features (e.g., the role of edges in color vision, the importance of shape over the color) designing color vision games could help in collecting data and have preliminary answers and research direction. Furthermore, the entertaining value of the test could be useful to test children or young people and could be of help in involving color deficient people without “torturing” them with long frustrating tests.

Issue	Tips and trick
Devices’ variability	Use standard sRGB color spaces Decrease color saturation Outcomes averaged over a large set of subjects
Large amount of data to manage	Set real time data classification system Focus on the most important data Set up an online data visualization environment Define your privacy policy
Test gamification	Design some levels for fun and some levels for test Create players rankings Set up prizes or advantages for the best player

Tab. 1 - Summary of main issues in designing online tests for color deficiency data collection and possible solutions.

In Tab. 1 are reported some possible issues in designing online games to test color vision deficiency and some tips and tricks derived from our experience.
Variability among devices is probably the most difficult issue to address, especially since the simple browser-based games here discussed are intended to be played mainly on smartphones. On one hand it is true that the industry of mobile devices is becoming more attentive to color management, for example Android OS starting from version 8.0 released in 2017 enabled support for wide gamut displays covering DCI-P3 color space along with a simple calibration procedure, Apple is also using wide gamut displays covering almost up to DCI-P3 since the iPhone 7 release in 2016. On the other hand, profiling and calibration procedures are still too simple, like the ones used in Android devices which offer few parameters and are extremely subjective; or completely lacking, like in iOS devices.
Another factor that must be considered is the browser's color management. While Safari for iOS implements gamut mapping using the actual color profile of the device as target color space, in Chrome for Android gamut mapping is implemented using exclusively sRGB as target (or DCI-P3 in devices supporting it), regardless of the actual display profile (EIZO, 2022).
Having to deal with this situation it is mandatory to carefully design the game and the choice of colors, following are some guidelines we came up with:

- Use sRGB color profile since most devices don't support other profiles.
- sRGB is default thus does not need to be explicitly defined while using CSS directives or HTML5 Canvas elements but should be embedded in all images used in the game (W3C, 2022).
- Avoid the use of highly saturated colors since it's more likely for a color near the edge of the sRGB gamut to be rendered unalike between two devices with different non-profiled non-calibrated displays.
- Include in the game at least some levels that are identical or very similar among all the players, so that gathered data can be averaged to address variability and outliers identified and excluded from data analysis.

Large amounts of data gathered from different people and devices are mandatory to offer some reliability and confidence during analysis, but at the same time pose some challenges that should not be overlooked.

The game we developed, which we will discuss further below, is designed to exchange very small sub-kilobyte messages with the hosting server once every few seconds, despite this we experienced a bandwidth usage of over 500mbps just hours after the release, hence care must be given to choosing the right metrics and data to collect, avoiding redundant or superfluous information.
Real time online data visualization and analysis comes in handy when dealing with a dataset in the region of the hundreds of thousands of entries, so that analysis can be performed without downloading and separately processing gathered data.
Given the fact that a user will hopefully play several times, a good practice might be to keep track of its device using cookies and the browser's local storage, thus allowing to keep a record of the player's behavior throughout time, which helps in identifying outliers as sudden changes in playing performance that might be due to environmental factors or learning. But using cookies and local storage requires the end user to explicitly accept a privacy policy, which might keep some people from effectively interacting with the game.
Regarding gamification, a balance needs to be found between the need for meaningful data collection and the player's leisure and satisfaction. Having a game that's too difficult might influence collected information, since errors might be due to the game's difficulty rather than actual phenomenon arising solely from visual perception limits (which we want to test), on the other hand having a game that's too simple might result in a poorly engaging experience. What we did was not to try and gamify a test, but rather design a simple game that could also be used to harvest information; hence we carefully designed some levels which are effectively used for testing and research and others whose main purpose is challenging the player and keeping them engaged.

A practical example
In order to better study the usage of games for data collection we are currently developing a simple game called Qolour. In Fig. 1-a is shown the main interface, as can be seen the player is presented with seven differently colored shapes arranged in a circular fashion, in the center there's a slightly bigger shape surrounded by an animated timer; at the top a global ranking informs the user of its actual position in the global ranking among the other players while at the bottom are displayed its current level, gained points and lives left. The purpose of the game is to press, before the timer expires, on the outer shape with the same color as the central one.

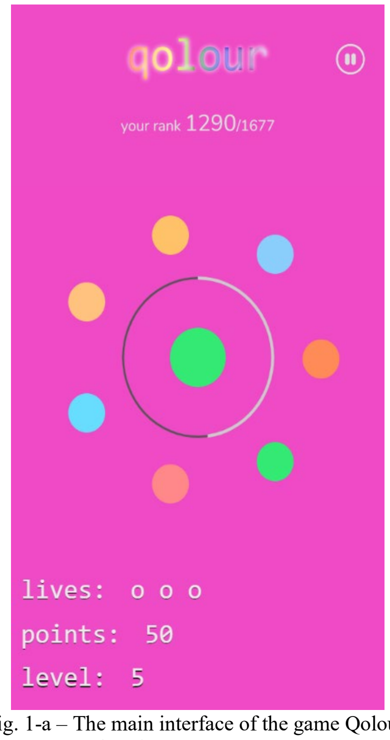

Fig. 1-a – The main interface of the game Qolour as seen on qolour.it.

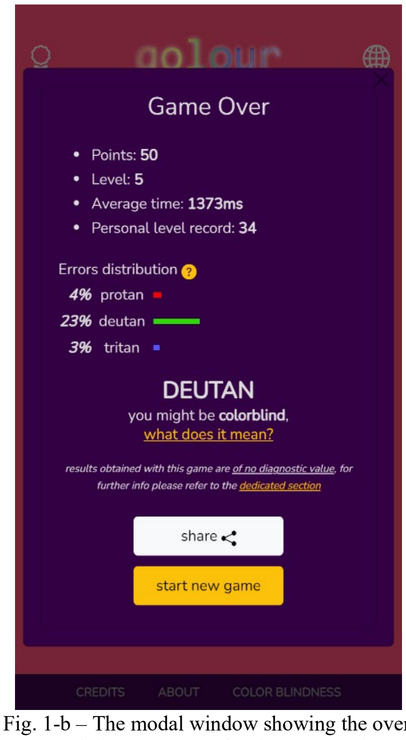

Fig. 1-b – The modal window showing the overall score and the assessment for the game Qolour.

The timer duration ranges from a minimum of 4 up to a maximum of 8 seconds and serves two main purposes: it increases the difficulty making the experience more challenging and renders more difficult for the end user to use strategies and tools to tamper with the game (e.g., using the browser's debugger to find the exact hex values of the shapes' color). Having noticed that some users had difficulty with tight timings, we decided to implement an adaptive timer, which increases in steps of half a second every time the player makes a mistake, up to 200% the initial time.
The central color, which we will call the *target color*, is generated randomly inside the HSL space, and subsequently converted to RGB, with the Hue being completely random, Saturation bounded between 0.6 and 0.8 and Lightness fixed to 0.5; since this setup is intended to gather data regarding the influence of spatial arrangement on color perception of Color Deficient Observers (CDOs) we decided to keep Lightness fixed in order to remove any variability that might be due to the variation of intensity between different rounds. One of the *outer colors* is the same as the target color, while the remaining six are chosen as to lie on confusion lines corresponding to the three types of dichromats, with the distance (measured in linear-RGB space) from the target color inversely decreasing with levels, so that as the user advances in the game the overall difficulty is increased.

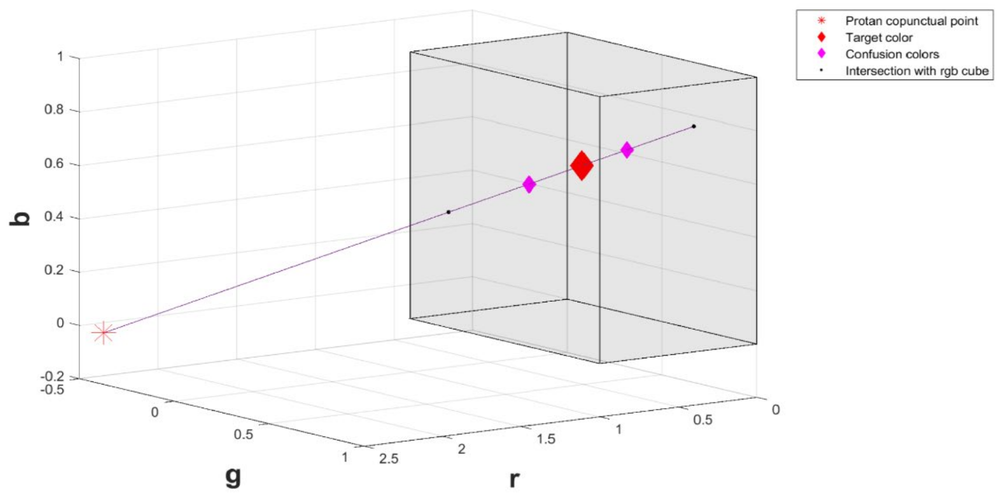

Fig. 2 - Representation of how the confusion colors are computed in linear-RGB space for a given type of dichromacy. The example in figure shows the line originating from the protan copunctual point with the same brightness as the target color, computed in linear-RGB coordinates. Along the segment connecting the two intersections between the ray and the cube, confusion colors can be sampled and gamma-corrected afterwards.

The linear-RGB space is not a perceptually uniform color space, but for practical reasons a choice has been made to compute distance in this space rather than in the perceptually uniform CIELAB space. Confusion lines are lines in the XYZ and linear-RGB spaces (being the transformation between the two linear), so, as shown in Fig. 2, it is easy to compute the coordinates of the two intersections with the linear-RGB cube's faces and a line originating from the copunctual point and intercepting the target color, thus allowing to compute any confusion color simply sampling along the segment connecting the points of the two intersections and later applying a proper gamma correction to transform the color into the sRGB space. In the example depicted in Fig. 3, it can be seen that straight confusion lines turn into nonparametric curves when working in the CIELAB space (but the same applies to other perceptually uniform spaces), thus rendering it difficult to reliably compute confusion colors without sampling the whole space. Since in our setup the target color is, as said, randomly chosen and the outer colors are computed client-side in real time, we faced the need for a fast and reliable computation, at the cost of perceptual uniformity, which is a problem that can easily be addressed later when performing data analysis.
In Qolour, the background color changes with each level and it can randomly be achromatic (having the same Lightness of the target color) or colored (a pseudorandom color computed such that it has the opposite Hue of the target color plus or minus 10 degrees but the same Lightness and Saturation). Data obtained with a gray background are used to roughly estimate a deficiency

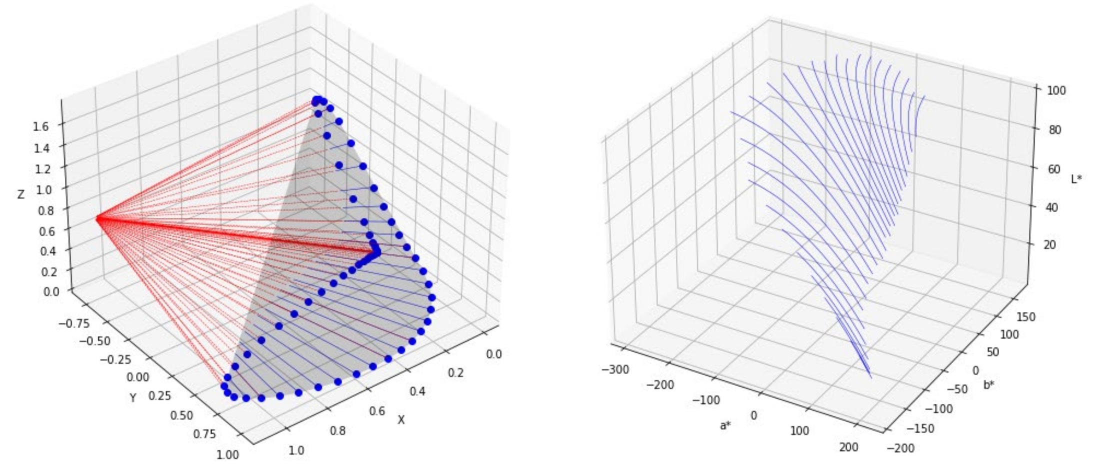

Fig. 3 - Left: protan confusion lines in XYZ space originating from the copunctual point towards the spectral locus (blue dots); the blue portion of the lines is the one falling inside the visible region of the XYZ space. Right: corresponding confusion curves plotted in CIELAB. In this example the copunctual point in XYZ is computed from the xy coordinates as to have Y=y and X+Y+Z=1.

coefficient that helps in segmenting the users between supposed CDOs and supposed Color-Normal Observers (CNOs), while the differences between the outcomes with colored and gray backgrounds are used to highlight possible contributions of the spatial context in the perception of colors.

Along with changing backgrounds and colors, the shapes can be displayed normally, with a blurred border (box blur via a kernel of approximately 10% the width of the shape) or a solid white border (having a width of approximately 5% the width of the shape). The shapes are always displayed without a blurred or a white border for the first 10 levels, as the role of the first 10 levels is to show the user how to play but are displayed randomly in one of the three configurations with a probability of 1/3 for the next levels. Every time the player picks the right color it gains 10 points and advances a level, every time it fails it loses points proportionally to the current level, if the timer expires it loses a life. The game ends whenever the user reaches 0 points, or 0 lives left; the global ranking is based on the maximum level the user has managed to reach. At the end of the game, as can be seen in Fig. 1-b, a modal window is displayed showing some statistics related to the progress, two buttons to play again or share the current score and a simple error distribution along the three possible directions towards the copuncutal points. As a bonus, a hint suggesting whether the user might be colorblind is shown, with a detailed explanation regarding color blindness and how data can be interpreted. This little assessment serves no diagnostic purposes and is intended solely to better engage the users' attention and give them some information regarding color blindness.

The estimated deficiency is determined based on two scores computed for both deutan and protan directions. The score *Score(d,u)* for each player *u* (*user*) and deficiency type *d* (*protan*, *deutan* or *tritan*) Eq. (1) takes into consideration the error rate *E%(d,u)* Eq. (4), which is simply the percentage of errors committed along the confusion lines of deficiency *d* for the player *u*, and the median of all the $\Delta E_R(r,u)$ for the player *u* in all the rounds $R_{d,u}$ for which the picked color lied on the confusion lines of deficiency *d* Eq. (2). $\Delta E_R(r,u)$ Eq. (3) is computed as the ΔE between the target color $t_{r,u}$ of round *r* and the color $p_{r,u}$ picked by the player *u* in the round *r*, relative to the maximum ΔE between the target $t_{r,u}$ and each of the outer colors *c* shown to the player *u* in the current round *r*. Since most of the errors are made with relatively small ΔE, a logarithm is used in Eq. (1) to emphasize low values and its argument is chosen to obtain a positive value bounded between *0* and *1*. The score ranges from 0 to 100, the higher the value the more frequent and/or severe the errors committed along a certain set of confusion lines.

Eq. (1) $$Score(d,u) = E\%(d,u) \cdot log_{10}[1 + 9 \cdot \widetilde{\Delta E_R}(d,u)]$$

Eq. (2) $$\widetilde{\Delta E_R}(d,u) = median[\Delta E_R(r,u)] \mid r \in R_{d,u}$$

Eq. (3) $$\Delta E_R(r,u) = \Delta E(p_{r,u}, t_{r,u}) / \max\left(\Delta E(c, t_{r,u})\right) \mid c \in OuterColors_{r,u}$$

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Eq. (4) $E\%(d,u) = 100 \cdot Errors(d,u)/Rounds$

A set of 16 control subjects, composed of 8 CDOs and 8 CNOs, have been given a special link to play the game so that we could compare the actual impairment of each one with the estimate resulting from the game. In distinguishing between CDOs and CNOs the metric used in our game resulted in a 100% success rate among this control group.

In a subsequent release a small optional survey has been added to the game interface, asking the users whether they know or think they might have any form of color deficiency. 12 out of 12 players who responded saying they have a Color Vision Deficiency (CVD) were flagged as CDOs by our game, while 32 out of 35 users who responded saying they never experienced CVDs were flagged as CNOs.

Nickname	**Deficiency**	**E%(protan)**	**E%(deutan)**	**Score(protan)**	**Score(deutan)**
ehi.pluto	Protanopia	**23%**	11%	**15.91**	9.86
minicartar	Protanomaly	**10%**	3%	**4.64**	3.53
areific	Deuteranopia	12%	**37%**	8.73	**30.04**
imwaffe	Deuteranopia	9%	**21%**	4.88	**14.92**
gustav	Normal	4%	3%	0.35	0.48
troots	Normal	4%	3%	0.70	0.74

Tab. 2 - Table showing the error rates and scores for 6 out of the 16 subjects in the control group, for which the deficiency was established using both Ishihara Plates and Anomaloscope.

In Tab. 2 are shown the error percentages and the scores obtained along the two sets of possible confusion lines for the subjects in the control group; only 6 out of the 16 subjects are shown for means of readability. Errors and scores along the tritan lines are not shown since for the time being it has not been feasible to include tritan subjects in the control group, making it impossible to evaluate the effectiveness and accuracy of our data analysis. Error rates are calculated as the ratio between the number of errors committed by selecting a color belonging to the specific set of confusion lines over the total rounds the user played as shown in Eq. (2), while scores are computed as shown in Eq. (1). It can be seen that subjects manifesting a form of dyschromatopsia presents a higher error rate and score with respect to the normal trichromate subjects along both directions, while both dischromatoptics and anomalous trichromats shows only higher scores in both direction with respect to normal subjects, but similar error rates. Looking both at the error rates and the scores it can be seen that the maximum value coincides with the actual deficiency observed in the user. A player is marked as normal if at least one of the scores is less than 1 and deficient otherwise, with the specific direction determined by the maximum value among the two scores.

At the time of writing, data collection is still undergoing, and metrics might face changes and improvement in the near future, but the aim of this preliminary analysis is to ascertain whether variability in devices, viewing conditions and attention levels are by any means tolerable for objective data gathering, which seems the case given the high success rate of this preliminary assessment. This game is part of a research project started in 2014 (Eschbach, *et al.*, 2014; Rizzi, *et al.*, 2014) and enhanced in (Eschbach and Nussbaum, 2021) which aims at determining the role of the scene spatial arrangement in color vision, for CDOs and CNOs. The research project is still in course and the results of this color vision online game will be soon published.

Conclusion

Today, to screen and assess color blindness and color vision deficiency there are several clinical tests, which require qualified medical personnel, high concentration by the observer and often a preliminary observer education on the use of the instruments. These requirements are necessary to have a diagnosis with high rate of reliability but could be unsuitable for young children or people with behavioral problems. In this context, the development of web-based tests could be a solution to gamify classical clinical tests and collect large amounts of data, to make research, improve the current diagnosis methodologies and raise the awareness of common people to color vision issues. Clearly, an online test could never substitute a clinical test, but could be useful to sensitize the general public on color vision issues and to help researchers in collecting data and developing innovative color vision tests.

In this paper, we investigated the usage of a web-based game as a source for larger amounts of data related to color perception, providing some tips and tricks to design online color games and providing possible solutions. In addition, we also present a practical example: the game Qolour. This game has been specifically developed to study the role of borders and edges in color vision, but its implementation could be an example for any kind of research in color vision.

The main advantage of online games is the large amount of data which could be collected in a short time, and which could provide an overall averaging of the outcomes and a consequent increase of reliability and confidence during analysis. Furthermore, the user engagement in progressing the game provides data reliability, together with the possibility to involve in the study also children or young people.

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Loss of colour and flicker sensitivity in subjects at risk of developing diabetes

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Keywords: colour vision, flicker thresholds, pre-diabetes, CAD test

Introduction

The primary purpose of this study was to investigate whether clinically normal subjects, but at risk of developing diabetes, show significant loss of colour vision or / and rapid flicker sensitivity with either rod- or cone-enhanced stimuli. Previous studies carried out in diabetic patients with no retinopathy revealed significant loss of chromatic sensitivity ranging from just below normal limits to complete absence of both Yellow/Blue (YB) and Red/Green (RG) chromatic sensitivity (1-4). This study examined whether subjects who are simply at risk of developing diabetes exhibit any significant losses of either colour vision or rapid flicker sensitivity when compared to age-matched controls.

Methods

Three subject groups were recruited from a healthcare centre offering diagnostic and screening services: G1 (the 'normal' subject group, n = 40, had no identifiable risk factors for diabetes and no history of eye disease); G2 (the 'high-risk' subject group, n = 150); and G3 (the subjects diagnosed with diabetes, n = 23). To be included in G2, a person had to present with three or more recognised risk factors for diabetes (see Table 1). RG and YB colour vision and flicker thresholds for rod- and cone-mediated vision were measured in each subject using a number of advanced vision and optometric tests (AVOT)(5).

The study was conducted in Kuwait in a Multi Specialized Medical Centre which offers visual diagnostic and screening services, including vision assessment for patients with diabetes. Participants were of Middle Eastern ethnicity. Three subjects were identified to have congenital colour vision deficiency and were therefore excluded from the study, 3 from G2 and 1 from G3. There was no difference in the gender distribution of participants across the three groups. The mean age of the groups was 37.2 ± 1.54 years, 38.12 ± 0.87 years and 58.1 ± 1.93 years, for the 'normal', 'high-risk' and 'diabetic' groups, respectively. The age difference between the first two was not significant ($p>0.05$). However, the mean age for G3 was slightly higher than for the other two groups ($p<0.05$).

Table 1: Risk factors for type 2 diabetes

Age ≥ 45 years
History of smoking
Overweight (BMI ≥ 25kg/m^2)
Family history of diabetes (i.e. parents or siblings with diabetes)
Habitual physical inactivity
Hypertension (≥ 140/90 mmHg in adults)
History of vascular disease
Previously identifed Impaired Glucose Tolerance (IGT) or Impaired Fasting Glucose (IFG)

Adapted from (6)

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Results

The results show that all G1 subjects had a visual acuity better than 6/9, as well as functional contrast sensitivity values within the normal range. They had rod- and cone-mediated flicker thresholds and RG and YB colour thresholds below the upper limits for the corresponding age. G2 subjects had significantly higher RG and YB thresholds when compared to the normal participants (Figure 1). G2 had rod- and cone-mediated thresholds that were also significantly higher (Figure 2). These subjects also exhibit a loss of function contrast sensitivity under photopic conditions, but the worsening of spatial vision and the inter-subject variability were much greater in G3 subjects when compared to the normal group. The G3 subjects also had the highest colour vision thresholds (Figure 1) and demonstrated the highest loss in rod- and cone-mediated flicker sensitivity (Figure 2).

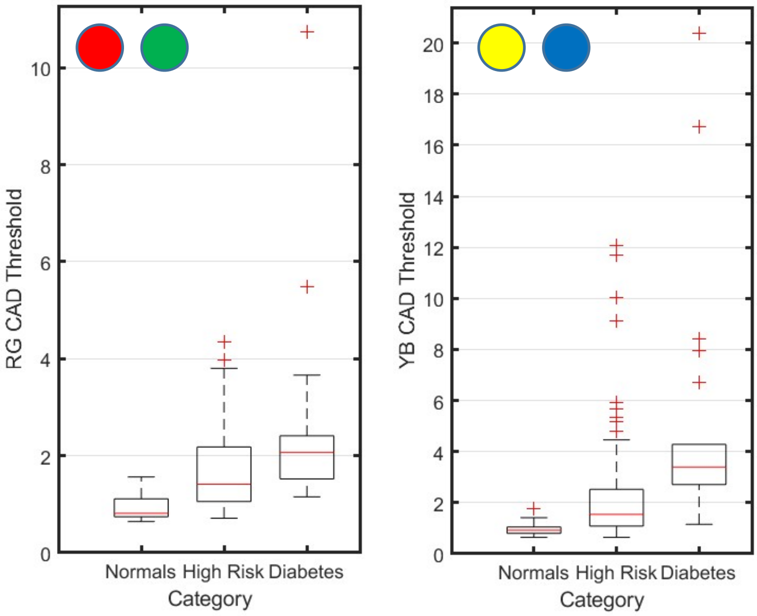

Figure 2: The distribution of (left) red-green (RG) and (right) yellow-blue (YB) CAD thresholds for the group of normals (G1), high-risk (G2) and diabetics (G3). Kruskal-Wallis test revealed significant differences between the three groups: H statistic is 54.949 for RG and 69.5633 for YB (2, N = 209), p-value is < .00001. The result is significant at $p < .05$ for both RG and YB. The results are shown using box plots where the median CAD threshold (red line) and the interquartile range are shown for each plot, as well as any outliers (red crosses).

Conclusion

The findings from this pilot study confirm and extend previously reported results in patients with diabetes (7, 8). Subjects in the high-risk subject group (G2), who did not meet the clinical criteria for diabetes, showed significant loss of both colour vision and rod- and cone-mediated sensitivity. These findings suggest that both RG and YB colour vision thresholds and rod- and cone-mediated rapid flicker sensitivity tests capture best the loss of functional vision in G2 and may therefore be considered as important risk factors in pre-diabetic screening.

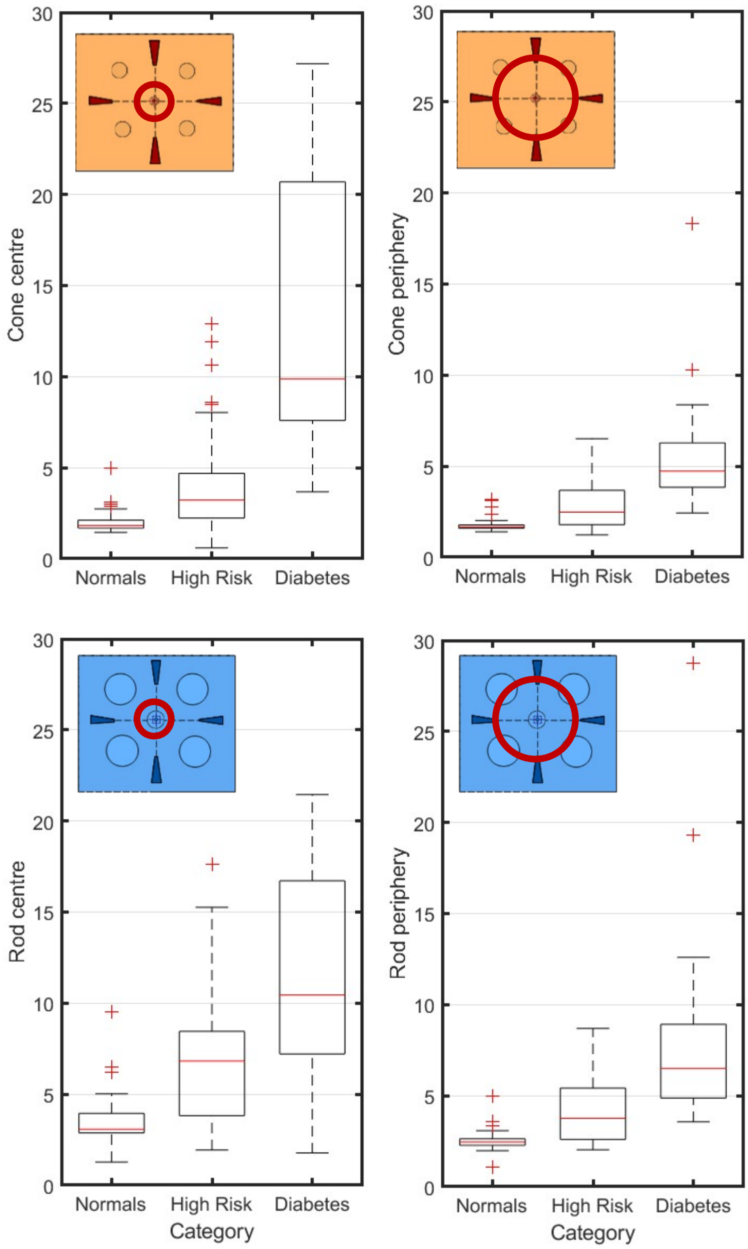

Figure 3: The distribution of flicker modulation thresholds for (top) cone and (bottom) rod mediated vision for both the centre and the periphery at an eccentricity of 5° away from fixation, for the three groups of interest. Again, the Kruskal-Wallis test revealed significant differences between the three groups for all four areas of measurement: The H statistic was as follows, cone centre is 77.6366, cone periphery 68.8356, rod centre 50.6031 and rod periphery 64.4944, all with p-values < .00001.

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Subclinical changes detected in diabetes mellitus using high resolution retinal imaging and colour vision assessment

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Keywords: Diabetic retinopathy, colour vision, adaptive optics

Background

Diabetes Mellitus (DM) affects approximately 415 million people worldwide (Ogurtsova *et al.*, 2017), and it has been postulated that this will increase to 700 million people by the year 2045 (Amoaku *et al.*, 2020). Almost all patients with Type I (T1) and at least 60% of patients with Type II (T2) DM will develop diabetic retinopathy (DR) after 20 years (Fong *et al.*, 2004).

Once the features associated with DR (i.e., microaneurysms, haemorrhages, cotton wool spots, exudates, oedema or venous abnormalities (Ghanchi, 2013)) are detected clinically, irreversible damage has often already occurred (Bhatwadekar *et al.*, 2021). Highly sensitive measures of both structure and function are therefore needed to detect DR in its earliest stages.

Here we use two highly sensitive measurement tools to determine whether early loss of colour sensitivity in DM is also accompanied by decreased cone density: 1) Adaptive optics scanning light ophthalmoscopy (AOSLO), which enables high resolution imaging of the retinal photoreceptors in vivo; and 2) the Colour Assessment and Diagnosis (CAD) test, which enables accurate diagnosis of both the type and severity of colour vision loss.

Methods

A total of 16 participants: 8 with DM and 8 healthy controls were enrolled in the study. This study adhered to the tenets of the Declaration of Helsinki and was approved by the local NHS review board (*IRAS: 289911*). Written informed consent was obtained from all patients after the nature and possible consequences of the study were explained and before any study procedures began.

Red-green (RG) and yellow-blue (YB) colour detection thresholds were measured using the CAD test (Barbur, Rodriguez-Carmona and Harlow, 2006). Confocal AOSLO images of the central photoreceptor mosaic were obtained and cone density was measured at 0.5° and 1° eccentricity along the temporal meridian, using 55 x 55 µm regions of interests (ROI).

Results

Seven patients with DM had higher colour thresholds than expected for their age. Median thresholds were significantly higher in patients with DM than healthy controls (Table 1).

		Controls			Patients with DM			p-value
		n	Median	IQR	n	Median	IQR	
CAD threshold	RG	8	1.26	0.30	7	3.23	3.31	0.006
	YB	8	1.53	0.47	8	2.94	3.26	0.021
Cone density (cells/mm^2)	0.5 T	7	70,687	17,586	8	61,772	22,847	0.463
	1T	8	54,201	6,424	8	50,643	25,780	0.888

Table 1. Cone density and colour vision thresholds for healthy controls and patients with DM.

There was no statistically significant difference between median confocal cone density, at either of the locations measured (0.5° and 1° temporally {0.5 T and 1T}), in patients with DM compared to healthy controls (Table 1). Despite this, the AOSLO images revealed abnormalities in the reflectivity of the photoreceptors in patients with DM that were not clinically detectable in their colour fundus images.

Discussion

In agreement with previous literature (Barbur, Ansari and Canning, 2012; Rodriguez-Carmona, Bastaki and Barbur, 2019), we found higher colour thresholds in patients with DM than healthy controls. Although there was generally lower cone density in patients with DM than in controls, the difference was not significant, again most likely owing to the high variability in cone density (Song et al., 2011). However, we did observe subclinical photoreceptor changes with AOSLO in the DM group that were absent in the normal group. Such changes are difficult to capture using current methods, as their locations vary and may not fall within the ROIs that were pre-defined as part of our protocol. Alternative analysis techniques, such as spacing metrics, Voronoi analysis, or artificial intelligence – particularly those that assess the mosaic across the entire montage – could potentially provide a valuable screening tool for early detection of DR. Larger sample sizes with greater representation across DR disease stage is needed for more definitive conclusions, but these results are showing promise in their ability to detect DR changes before they present in the clinic.

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Foveal cone structure in patients with blue cone monochromacy

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Abstract

Purpose: Blue cone monochromacy (BCM) is a rare inherited cone disorder in which both long- (L-) and middle- (M-) wavelength sensitive cone classes are either impaired or non-functional. Assessing genotype-phenotype relationships in BCM can improve our understanding of retinal development in the absence of functional L- and M-cones. Here we examined foveal cone structure in patients with genetically-confirmed BCM, using adaptive optics scanning light ophthalmoscopy (AOSLO).

Methods: Twenty-three male patients (aged 6 – 75 years) with genetically-confirmed BCM were recruited for high-resolution imaging. Eight patients had a deletion of the locus control region (LCR) and 15 had a missense mutation, Cys203Arg, affecting the first two genes in the opsin gene array. Foveal cone structure was assessed using confocal and non-confocal split-detection AOSLO. Axial eye length was measured and used to scale all images.

Results: Only 1/8 patients with LCR deletions and 10/15 patients with Cys203Arg mutations had analyzable images. Mean total cone density for Cys203Arg patients was 16,609 ± 11,162 cones/mm2 (n = 10), which is, on average, around 40% of normal. Waveguiding cone density was 1,814 ± 981 cones/mm2 (n = 9), which was consistent with published histological estimates of S-cone density in the normal eye. The one patient with an LCR deletion had a total cone density of 9,834 cones/mm2 and waveguiding density of 968 cones/mm2.

Conclusions: Our results show that BCM patients with LCR deletions and Cys203Arg mutations have a population of non-waveguiding photoreceptors, although the spectral identity and level of function remain unknown.

Keywords: Colour vision, Retina, Cones, X-linked, Blue cone monochromacy, Adaptive optics, Retinal imaging, Genotype, Phenotype

Changes in the 'conspicuity' of coloured objects caused by coloured lenses and / or pre-receptor filters in the eye

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Keywords: colour vision, cone contrasts, blue light, macular pigment, effective contrast, contrast enhancement, CAD test

Background

When the visual world surrounding us is imaged on the retina by the optics of the eye, all available information is encoded in this image as spatial and temporal variations in intensity and / or spectral content. Of particular interest are edges and boundaries which help define objects and areas of interest. The perceived 'conspicuity' of coloured objects, a quantity that relates directly to visual performance, is often determined by a combination of colour and luminance contrast signals[1 2]. When coloured objects are involved, the wavelength composition of the ambient light, the spectral absorption of any coloured filters external to the eye and / or pre-receptor filters within the eye can cause significant changes to luminance and colour contrast signals and hence to the visual appearance of the objects we see. The expression of variant cone-pigment genes in some subjects, large differences in L/M cone ratio or the absence of either L or M cones in red / green dichromats can produce large deviations in both luminance and colour contrast signals with inevitable consequences on visual performance[3]. The purpose of this study is to explore how changes in these parameters can enhance or diminish colour appearance and the conspicuity of coloured objects.

Methods

We examined how thresholds for detection of red / green (RG) and yellow-blue (YB) colour differences relate to cone contrasts when the state of chromatic adaptation of the retina corresponds to daylight (D_{65}). We used the CIE (x,y) chromaticity diagram to alter systematically the spectral composition of the test target so as to measure colour thresholds along chromatic displacement directions away from daylight chromaticity. We then used the normal, cone-pigments spectral responsivity functions and the spectral radiance of the stimulus to calculate the cone-contrasts needed at threshold when one can just discriminate RG and YB colour differences[4]. We also repeated the same experiments under conditions of chromatic adaptation over a range of retinal illuminances to establish how the level of photoreceptor excitation affects cone photoreceptor contrasts at threshold[5]. The invariance of cone contrasts at threshold made it possible to model chromatic discrimination sensitivity for different states of chromatic adaptation and retinal illuminance level. We were also able to model how coloured filters external to the eye as well as pre-receptor filters within the eye alter the state of chromatic adaptation of the retina and hence the measured RG and YB colour thresholds. The generic model developed in this investigation allows for the use of variant cone pigments, as expected in subjects with congenital colour deficiency, and the normal variation in L/M cone ratio. The model also computes subject-specific deviations from isoluminance as a result of variant L- and M-cone pigments, pre-receptor filters and unusual L/M cone ratios.

Results

The results show that with the exception of a narrow range of chromatic displacement directions that correspond to the tritan axis, colour detection thresholds measured in young, normal trichromats are mediated entirely by the RG chromatic mechanism. The corresponding, polarity sensitive, median, L- and M-cone contrasts at threshold in young subjects are ~ 0.4% and ~ 0.8%, respectively. In comparison, the yellow-blue mechanism requires ~7% contrast to reach threshold[4]. The results also show that these cone contrasts at threshold remain invariant with cone excitation and follow Weber's law. An exception to this was observed when examining yellow-blue thresholds at lower light levels when S-cone contrast thresholds were found to increase more rapidly with decreasing S-cone excitation[5].
External, blue-blocking filters cause systematic shifts in chromaticity, approximately along the daylight locus, with little or no effect on either RG or YB thresholds. More surprisingly, moderate absorption of short wavelength light by the macular pigment or / and the lens has equally small effect on colour thresholds under normal photopic levels of ambient illumination. This was, however, no longer the case under lower ambient illumination. The further decrease in S-cone excitation in older subjects caused by selective absorption of short-wavelength light by the macular pigment and the lens can cause significant loss of YB chromatic sensitivity, even when YB colour vision remains normal at higher ambient light levels. Not unexpectedly, when external coloured filters block large amounts of short wavelength light, the model predicts significant loss of YB chromatic sensitivity, matching well the experimental observations.

Conclusions

The cone contrasts needed to detect RG or YB colour signals at threshold remain invariant with cone excitation level and follow Weber's law. This is less so when examining S-cone thresholds which increase more rapidly with decreasing S-cone excitation at lower light levels. The generic model based on these findings predicts colour thresholds under conditions of chromatic adaptation which includes the effects of coloured filters external to the eye as well as pre-receptor filters within the eye. Blue-blocking filters employed in typical spectacle lenses used with daylight illumination cause only small shifts, approximately along the daylight locus, without any significant loss of either RG or YB chromatic sensitivity. Older subjects with high levels of macular pigment and stronger absorption of short wavelength light by the lens in the eye can experience reduced YB chromatic sensitivity, particularly at low ambient light levels. Other model predictions such as the enhanced or diminished conspicuity for coloured objects in subjects with congenital colour deficiency remain to be validated experimentally.

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A leap in the dark!
How understanding horses' color perception improves their performance and welfare in show jumping

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Abstract
In horse showjumping, the probability of falls at jumps also depends on the horse capacity to see obstacles. Experimental works have confirmed the correlation between obstacle colors and jumping performance. Horses are dichromats: they can see blue and yellow, but they are not able to clearly distinguish red, orange, and green. The available results in this field, however, can be hardly compared, because the different authors have not characterized colors in terms of any standard system. Moreover, the reported computer simulations of how colors would presumably appear to horses look quite different, even when input colors are similar. Color design can contribute to fill some of these gaps. To this end, this paper firstly summarizes the horse visual system. A state of the art survey on color impact on the jumping performance is also reported, highlighting inconsistencies and problems that can be ascribed to a lack of familiarity with color science. A color analysis of a real jumping competition is finally presented, showing some key aspects that could be advantageously taken into account when the obstacle sequence is designed. The results reported in this paper can represent a starting point to define a systematic approach in the color design of jumping obstacles in horse competitions.

Keywords: horse vision, horse-rider synergy, contrast measure.

Introduction

Collecting information about the surrounding environment is crucial for survival, and most animals process that information primarily through the visual system. Ecology and life conditions shaped animal visual abilities and stimuli perception leading to a wide inter-species and inter-individual variability (Timney & Macuda, 2001). This mostly occurs in color discrimination, which varies based on the number and type of photopigments located in the eye cones (Carroll *et al.*, 2001). Knowing how animals perceive colors becomes essential to design products or environments for domestic species or in those activities involving human-animal coordination (Rørvang *et al.*, 2020). Showjumping is one of the most popular equestrian disciplines, attracting increasing attention on horses' welfare and safety. The probability of falls or injuries at jumps also depends on the capacity of the horse to see and respond to obstacles (Górecka-Bruzda *et al.*, 2011). The contrasting colors of obstacles with surrounding has been found to be decisive in perceiving the presence, the distance, and the size of the hurdle (Paul and Stevens, 2019). Horses (*Equus caballus*) are dichromats, with two eye cone types, sensitive to short and medium wavelengths. They can see blue and yellow, while they are not able to distinguish red, orange, and green, unless brightness, shade, texture, and other features are well integrated (Hanggi *et al.*, 2007).
The analyses of jump faults (obstacle knock-down or run-out) reported in literature confirm the correlation between obstacle colors and performance, highlighting the relevance of background colors, hurdle color schemes (monochromatic or polychromatic) and Light Reflectance Value (LRV) contrasts (Wyszecki, G. and Stiles, W. S., 2000). However, most of the results can be hardly tested and/or compared, because the colors used are not characterized in terms of a standard color system (i.e., the Natural Color System or the Munsell Color system). Also, the models used to predict the horse color vision are, in most cases, not specified, so that visual predictions of similar

colors shown in different studies look significantly different. Finally, the chromatic vision of riders could have a role in the jumping performance; nonetheless, this aspect has received little attention by researchers. This paper initially introduces the main features of the horse visual system. A literature revision on the impact of color on the horse jumping performance is reported, highlighting inconsistencies and problems that can be ascribed to a lack of familiarity with color science. Examples of obstacle color schemes (acquired by means of instrumental measurements) commonly used in jumping competitions or during training are analyzed. Finally, the paper proposes a framework with few procedural rules that can help in the design of obstacles for competitions and training. The results reported in this paper can represent a starting point to define a systematic approach in the color design of jumping obstacles in horse competitions.

The Horse Visual System

As prey animals, horses have evolved a visual system that allows them to constantly monitor the nearby environment; they need to detect potential predators in the long distance, to get ready to escape anytime. Their visual field has fostered a panoramic viewing system, with limited binocular capability (Timney & Keil, 1999). The binocular field of vision, which is 120° in humans, is only 55° to 65° in front of the horse (Hughes, 1977), and the overlap is predominantly below the head, extending down ~75° (Timney & Macuda, 2001). The visual input is stretched and wide, conferring a panoramic view with only a small blind spot at the rear. Horses have poorer acuity than most other terrestrial mammals, due to a low density of cones in the retina. Unlike the human's retina, the equine retina has no central fovea, while it presents what is known as a "visual strip" (Harman et al., 1999). This region, projecting towards both nasal and temporal directions, is characterized by a high-density of ganglion cells (Evans and McGreevy 2007). On the other hand, horses are hyperopic (Murphy et al. 2009), a characteristic which allows them to have good visual acuity for distant objects. To bring objects into focus, horses must lift, lower or tilt their heads. Whether the over-arched neck of the ridden horse in sports like dressage or showjumping would inhibit its ability to see what is directly in front of it, is a debated topic from more than a decade (Harman et al. 1999). Recent studies indicate that they can compensate for some head and neck rotation by rotating eyeballs; however, this does not counteract few hyperflexed positions (McGrevy et al., 2010). The recent increased awareness about horse welfare and the factors affecting the performance has induced riders in showjumping to allow their horses choose their own head carriage, for a better perception of the obstacle. Finally, another anatomical feature can influence horses' perception of obstacles. The tapetum lucidum is a light-reflective tissue present in the eyes of both vertebrates and invertebrates. Its location is close to the photoreceptors; it reflects light that was not absorbed by photoreceptors, and returns it to photoreceptors, so as to give them a second possibility to catch light. With this mechanism, the tapetum lucidum can increase visual sensitivity under low-light conditions (Shinozaki et al., 2013; Ollivier et al. 2004; Schwab et al. 2002), potentially altering the discrimination of colors.

Horses' color perception in relation to obstacles in showjumping

Horses' color vision is dichromatic, meaning that the sight is deficient in one of the three cone pigments, a condition also known as "red-green blindness" (Hanggi et al., 2007). It has been shown that the sensitivity curves of horses approximately present two peaks at about 420 and 539nm (Carroll, J. *et al.* 2001). Human color vision is trichromatic, i.e. photons absorb light in three classes of cones, whose peak sensitivity lie in the long-wavelength (L), middle- wavelength (M), and short-wavelength (S) regions of the visible spectrum. Reduced forms of color vision occur from the actual deficiency of one of the retinal photopigments (L, M, or S). Dichromatism results when the peak sensitivity of one of the primary cones shifted, and the amount of shift defines the color spans perceived. Along with the anatomical peculiarity of horse's eye, color perception is a pivotal aspect of the showjumping performance, most importantly for the selection of obstacle colors, as these may not perceived by horses as they appear to the human eye, and viceversa.

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In the literature, only few recent studies are available, comparing different obstacle colors without elaborating on the variability in color schemes or specific colors features. Stachurska et al. (2002) suggested that using white resulted in a largest takeoff distance, while bright blue produced a larger angle of takeoff; jumps over fluorescent yellow fences had shorter landing distances compared to orange. Later, Stachurska et al. (2015) highlighted the potential difficulty for horses to jump obstacles which are all light or all dark, since these may cause an optical illusion that leads to overestimating the obstacle size. Uniform dark may make the horse disregard the obstacle altogether. Paul and Stevens (2019) provided a comprehensive analysis of different colors and characteristics of colors in show jumping. Authors tested orange, fluorescent yellow, bright blue, or white obstacles, and found a correlation between obstacle color and both the jump angle and the jumped distance. Also, they took into consideration shade, texture, and/or brightness properties of the specific colors such as white, yellow, or blue which impact the attractiveness of these colors. Also, matt fluorescent yellow reliably has the highest contrast, in terms of luminance, of all the colors tested. Unfortunately, in all the available works discussed above, the authors have not adopted a standard color system to define the used colors, which are usually referred to with generic names or just shown in pictures. Moreover, the computer simulations of how the colors applied to obstacles could appear to the dichromat horses seem to provide quite different outputs, even when the input colors are similar. Also, sometimes the simulated colors do not seem to be reliable representations of color blind vision, at least compared to the results commonly obtained with available color blindness simulators. This lack of uniformity and proper color references could be overcome by the adoption of standard color systems and by defining a common model for color blindness simulations.

Color Analysis of the obstacles used in a real competition

To analyze the color schemes of the obstacles used in a real show jumping competition, instrumental color measurements were performed at Gorla Maggiore, Italy, 13-15 May, 2022, during the "Nazionale a 5 Stelle" Jumping Trophy. Specifically, the colors of all the obstacles used in the Trophy were acquired by means of a commercial colorimeter. Moreover, to further characterize the color patterns used for the obstacles, a Color Presence and a Color Distribution analysis were performed.

Color presence analysis

In color design, color presence analysis determines the set of colors used for a specific object. Fig.1 shows an example of the color acquisition process. On the left side, it shows a subset of the acquired colors, expressed according to the RAL color systems (Wyszecki, G. and Stiles, W. S. 2000); on the right, the corresponding simulations of how each color would presumably appear under protanopy conditions (Paglierani, P. and Valan, F. 2018), with the corresponding RAL codes. In fact, as discussed previously, the horse visual system presents spectral sensitivity curves with peaks not far from the human ones for blue and green, and the used tool allows to emulate this condition. The analysis shows that the obstacle colors seem to be chosen randomly, i.e. the visual features of the horse do not seem to influence in any way the color choice. Thus, the color scene as observed by the horse and the rider can result significantly different, and this could lead to a non-optimal perceptual agreement between them. Furthermore, this obstacle color choice could also lead to color combinations of obstacles and background that can be clearly perceived by the rider, but that could result problematic to the horse. This possibility seems to be further suggested by the color distribution analysis summarized in the next subsection.

Figure 1: Obstacle color acquisition and processing. On the left: real obstacles. On the right: dichromat vision simulations.

Color Distribution Analysis

The color distribution analysis identifies how colors are applied to objects. In this case, it allows characterizing the patterns used for coloring obstacles. The analyzed obstacles present different patterns, with one, two or three colors. Quite complex shapes are sometimes included in the obstacles, as well as decorations (shapes of flowers, leaves, etc.). One fundamental aspect to consider is the contrast that the obstacle color pattern can present w.r.t. the background. Notwithstanding the complexity of most the adopted color schemes, in some cases the obstacle still results not well visible to the rider with normal vision or to the dichromat horse. In some cases the obstacle results well visible to a normal visual system, but could be less identifiable to a dichromat. Also, the role of the background seen by the couple horse-rider plays a fundamental role. A careful choice of the obstacle colors that takes into account the visual background could render the obstacle more easily perceivable by horses and riders.

Obstacle Analysis examples

To start investigating the possible impact of obstacle color on the horse jumping performance, the colors of all obstacles used in two races during the “Nazionale a 5 Stelle” Jumping Trophy were analyzed, together with the final score of each horse/rider couple, officially recorded in the report released by the race judges. Although the carried out survey is clearly non-significant from a statistical point of view due to the small sample set, the analysis can provide useful hints for future research activities, and can sketch a methodology that, applied to a significantly larger number of competitions, will provide more reliable results. Pictures of the obstacles were also acquired in the field, together with the official obstacle sequence maps. Fig.2 shows the number of errors for each obstacle during the first analyzed competition (May 14, 2022, time: 11 a.m., obstacle height: 135 cm; lighting conditions: sunlight, no clouds, participants: 45). The histogram clearly shows that errors are not uniformly distributed among obstacles: in particular, obstacle number 5 originated 14 errors, while at obstacle number 7 no error occurred. It must be remarked that obstacle 5 was a combination, i.e. a sequence of two obstacles judged as one jump. This type of obstacles could cause more errors than simple fences or other types of obstacles, requiring a double jump in a constraint space. However, it could be observed that in other competitions during the event combinations were not the obstacles with the highest number of errors. Nonetheless, the obstacle type should be considered as a variable in the statistical analysis. Moreover, also the position of the obstacle in the field can have a role in the analysis. In this paper, however, the scope is a preliminary overview of the problem, and the impact of obstacle types and positions, as well as other factors of potential interest, will be considered only in a qualitative and comparative way. Type and position of the obstacle in the overall sequence will be further discussed in the following.

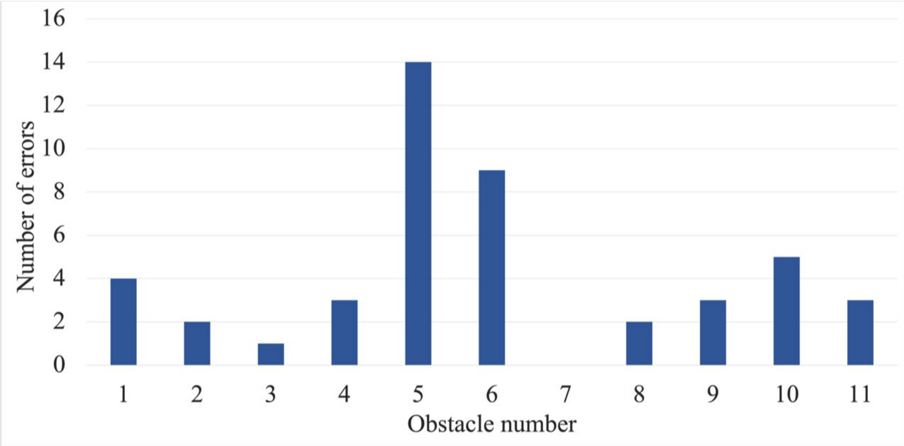

Figure 2: Histogram of the errors observed at each obstacle (first competition)

Figura 3: Pictures of obstacle 5 (left, max. error number), and 7 (right, min. error number) in the first analyzed competition.

Fig.3 shows obstacles number 5 and number 7. As one can clearly see, obstacle number 5 is not easily perceivable w.r.t. the background and the ground. This may have contributed to increase the difficulty of the jump. Conversely, obstacle 5 seems to be better perceivable to a normal visual system, and less to the dichromat horses. However, even for dichromats, obstacle 5 stands out quite clearly from the background. The results of a second jump competition are shown in fig.4. In this case, the obstacles were the same used in the previous competitions, but positioned differently in the race field, and in a different sequence. The height of the obstacles was 130cm, the starting time was approximately the same (11 a.m.), as well as the lighting conditions (sunlight, no clouds). The number of participants was 48. In this race also, the error distribution was not uniform, even if with a less pronounced peak than the previous one. The highest number of errors was observed at obstacle number 7, while the obstacle with the lowest number of errors was number 3. Quite interestingly, the same black obstacle 7 had had a low number of errors in the previous race (where it was obstacle number 9, with 3 errors) - when placed in a different position. Obstacle 7 was an oxer in this second competition, i.e. a double vertical fence with a space in the middle.

Obstacle 7 was a simple fence in the previously analyzed race. The gray obstacle 3 that here had the lowest number of errors, was the one with the highest number of errors in the previous competition (obstacle number 5). However, in this race this gray obstacle was used as a single fence, and not as

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a combination. Also, its position in the two race paths was different, and therefore so was the contrast with the background.

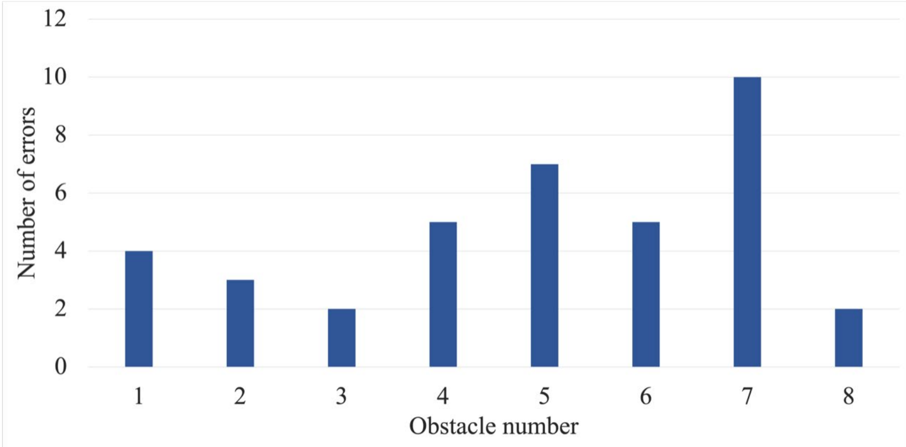

Figure 4: Histogram of the errors observed at each obstacle (second competition)

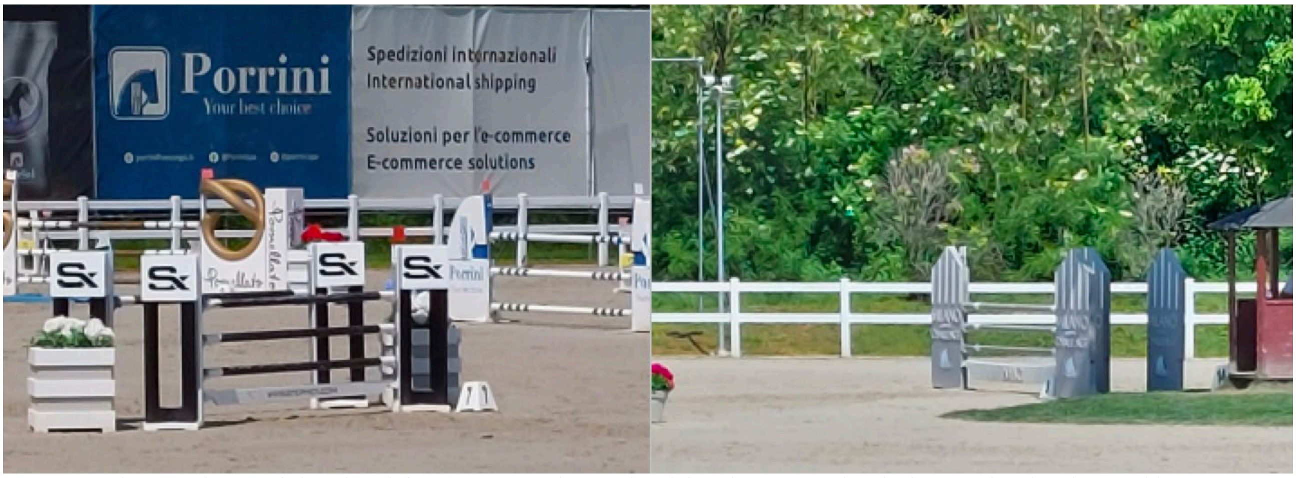

Figure 5: Pictures of obstacle 7 (left, max. error number), and 3 (right, min. error number) in the second analyzed competition.

Conclusions and future perspectives

The horse jumping performance can be influenced by a number of parameters: color of the obstacle, contrast with the background, lighting conditions, type of obstacle (fence, oxer, combination, etc.), position in the field and in the sequence, etc. Paul & Stevens (2020), Stachurska et al. (2015). In general, the performance can be the result of a complex combination of such factors, which could be difficult to predict. The contrast of an obstacle against its surroundings and the ground seems to play an important role: it can influence the determination of obstacle presence, size, and the distance between the viewer and the obstacle (Bruce et al., 2003). The analyzed examples have shown that the same obstacle, positioned in different places in different races with similar lighting conditions, can originate a significantly different number of errors. Moreover, the study of the horse visual system suggests that horses could be particularly sensitive to lightness. Thus, lightness, and in particular lightness contrasts, could play an important role in the jumping performance. The finishing of the obstacle, in particular its gloss, could be also important, as it typically plays a role in the vision of dichromats. Nonetheless, the impact of lightness contrasts and/or gloss and finishing of obstacles on the jumping performance, to the best of the authors' knowledge, has received minor attention from researchers. The horse color vision has been analyzed for the impact it could have on the jumping performance. Conversely, less attention has been paid to the color vision of riders. Since 8% of the male population is affected by color vision deficiency, a non-negligible fractions of riders could have color vision problems, and this could affect the jumping performance or the relationship horse-rider. To the best of the authors' knowledge, this aspect has never been considered in the literature.

Some basic rules for the design of obstacle colors and their use in competition paths can be provided. The selection of colors for the obstacles that result invariant under the specific horse color blindness can help control in a more accurate way the difficulty of obstacles.

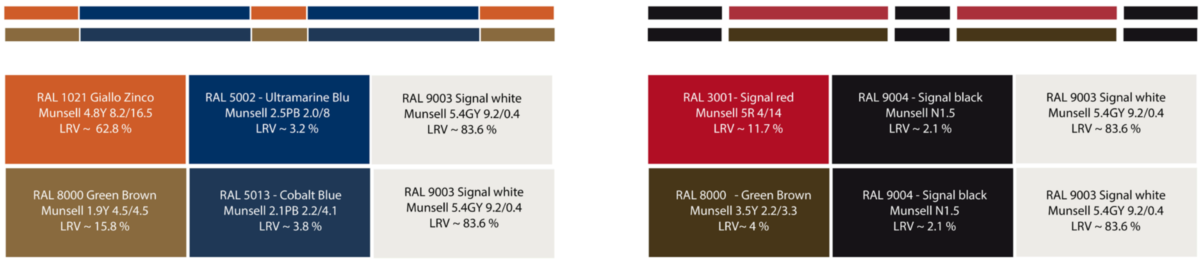

Figure 6: Dichromat invariant obstacle design.

Fig.6 illustrates an example of obstacle color design that takes into account horse color vision capabilities. The upper obstacle is a real obstacle pattern, whose vision by the dichromat horses would result distorted w.r.t. normal human vision. The lower obstacle is the simulated version of the upper one (i.e. it represents how the upper obstacle would appear to a dichromat). The table on the bottom of Fig.6 reports the colors of the shown obstacles in the RAL and Munsell color systems, together with their LRV. Using the colors of the simulated obstacles, one would obtain real obstacles appearing invariant both to normal and to dichromat observers. Such obstacles could be used in experiments on the impact of colors on the jumping performance, as well as during training, to create paths with controlled visual difficulties and improve the harmony in the human-horse interaction (Scopa C., *et al.* 2019). Investigating the color vision of riders is a future line of research for this activity. This aspect has received minor or no interest from researchers. Color deficiency of the rider could offer an advantage in creating a better harmony between rider and horse, resulting in improved racing performances. One of the planned activities in the follow up of this research will be rider color vision testing to verify a possible competitive advantage of riders with color deficiency. A hint on this comes from the famous horse rider and trainer M. Roberts, who suggests that his color blindness could have helped him in his relationship with horses (Roberts, M., 1997).

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Do color and light affect physiology and psychology in proportional ways?

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Abstract

The application of the studies on light and color for the wellness of human beings is relatively recent. For decades, the design field's primary concern has been to ensure an optimal level of illuminance for workers, passers-by, or tourists, paying attention, where possible, to energy saving. This fact is even odder when we consider that light and color have been studied since the fifth century AD. Even if the emotional impact of light and color on emotions has never been a mystery, the studies on their interaction with the human circadian rhythms found no relevant, productive application since the early 90s. This is another reason to emphasize the differences between physiology and psychology when humans interact with light and color. The relationship between these stimuli and human physiology has been carefully investigated. As a result, many discoveries have been made, like the existence of specific structures in the retina called ipRGCs (Intrinsecaly Photoreceptive Retinal Ganglion Cells) have been identified, containing a photosensitive protein called melanopsin, capable of carrying out the phenomenon of phototransduction (such as the other photoreceptors, cones and rods). The difference is that the electrical impulse created by these cells follows a different path from that of vision and is conveyed through the retina-hypothalamus tract, where it will affect the pineal gland by suppressing melatonin. This hormone is essential in the regulation of the human circadian cycle. These notions highlight a fundamental aspect: the influence of light and color on human physiology does not follow the exact mechanisms of the one of vision. Instead, and as far as we know, the emotional reaction results from the brain elaboration after a lighting stimulus is conveyed through the visual system channels. This difference is also evident in human sensitivity to the different wavelengths of light (various colors). For example, in the spectral sensitivity curve (which colors we see better), the maximum response coincides with 555 nm (yellow-green). In contrast, in the sensitivity curve concerning the circadian cycle, i.e. which wavelength affects the most, the maximum sensitivity corresponds to 460 nm (blue). In a nutshell, the differences between these two mechanisms are reflected in human beings' perception of color. For example, it is not uncommon for an individual to associate the term "activating" with warm and bright colors such as yellow and red, while, physiologically speaking, activating colors are at the opposite end of the spectrum (blue). The doubt arising from these observations is that a complex system like the one of human perception does not possess some form of convergence between these two mechanisms. In this paper, we will discuss the early stages of research that aims to understand if it's possible to find a proportion between the emotions and moods aroused by colors and their influence on our physiology.

Keywords: Light, Color, Physiology, Psychology, Design, Behavior.

Introduction

Much is known about the perception of light and how it is transformed through a physiological pathway into a mental representation of color. To date, all knowledge of this perceptual process has been investigated, as is often the case in neuroscience, through studies on patients with a pathology related to this specific aspect. A recent work comprehensively analyzes and reviews everything we know today about this process (Bosten, 2022), showing not only the differences related to patients with some color perception deficit but also possible differences between healthy individuals. The description of an elaborate scene or object will most likely be different from that of another person who is describing exactly the same scenario, varying not only in physical characteristics related to shape and color but possibly also in emotional responses and feelings triggered by it. Specifically, variability at all levels of the color vision process creates diversity in color perception, from discrimination to color matching and subjective experience, so each individual lives in a unique perceptual world (Helm and Tucker, 1962). Biology might suggest that healthy humans with the same anatomy react in a relatable way to certain stimuli. Still, the complexity of the interactions between psychological and physiological aspects of perception shows that this is not always true.

Theoretical background

The role of light and color is critically important when thinking about the design of indoor and outdoor spaces in a society such as ours that is constantly evolving, where productivity and sustainability are the basis for innovation. To achieve this goal, it is possible to bring an impact on human perception to modulate behavior; in fact, in the field of environmental psychology color plays a key role in this process. In the past, many studies on the perception of color and light in application mainly investigated the productivity of workers or students during their working hours, investigating which among various light sources or color could improve their performances (Phipps-Nelson et al., 2003). The attention of researchers also focused on applications of light and color for the physiological and psychological well-being of humans or a combination of them (Chen et al., 2022). Studies proved how light and color affects both people's physiological and psychological health through modulating parameters such as circadian rhythm, attention levels, and mood (Küller et al., 2006; Kakitsuba, 2020; Wang et al., 2020; Papinutto et al., 2020; Zhu et al., 2019). These studies are of fundamental importance for their application in people living and working environments. Still, it is necessary to set stakes and begin to make distinctions between some of the processes described. Undoubtedly, color is a very controversial stimulus, and its study is far from easy (Bortolotti et al., 2022).

Controversies.

In general, it is possible to state that color has three main physical characteristics of hue, lightness and saturation, each of which can affect our autonomic nervous system in some way and in return, create physiological and psychological responses (Al-Ayash et al., 2016; Wilms e Oberfeld, 2018). One of the controversies this article emphasizes is the difference between physiological (physical) and psychological (emotional) modulation of the perceptual process of light and color. These physiological and psychological processes are often, superficially, united as if they were a single process, when in fact, they are two distinct processes capable of influencing each other (Cacioppo et al., 1993). A first distinction that can be made is that psychological type processes that can be influenced by color can be: memory, attention, and perception (to name a few), while the physiological type processes are: breathing, sweating, heart rate, body temperature, wake/sleep cycle and others. As mentioned, they can influence each other, and emotions also play an important role (Valdez & Mehrabian, 1994). Therefore, comparing psychological effects to more or less conscious perception and physiological effects to occurrences (not conscious or not at all) is possible. These two processes might have different perceptual processing at the brain level, which we will call the “dual pathway” in this paper. These processes compose the perception of objects, scenes, and communication through color.

The emotional impact of light and colors on emotions has never been a mystery (Bortolotti et al., 2021; Elliot, 2015), although the study of color and brightness still has many controversies, such as the correct description of the concept of lightness (Bortolotti et al., 2022). Studies on their interaction with human circadian rhythms have not found relevant and productive applications since the early 1990s. Still, with the advance of LED and control technologies, lighting design is going in this direction (Rossi, 2019). According to the above, it is fair to distinguish between these two different types of color and light perception.

Dual pathway

A child asked to tell where the color will probably answer that color is part of the object. The same answer will probably come from many adults. However, color as a concept is “visible” only in people internal subjective world; it is humans subjective processing of the different wavelengths of light (Helm and Tucker, 1962). Color vision for humans can be described as ”trichromatic” because it is based on photoreceptors called “cones” that are sensitive to long wavelengths (L), medium wavelengths (M), and short wavelengths (S). However, this distinction may not be sufficient to fully explain the perceptual process related to light and the mental creation of color. This arises from the fact that this type of processing is very complex and, in some cases, “emotional” processing does not occur simultaneously in terms of temporal processing of the stimulus (Gao, and Xin 2006).

Cones (but also rods) are not the only specialized cells that are considered photoreceptors in the retina; in fact, it has been shown that light affects a distinct photoreceptor in the eye, a specialized type of proteic photopigments that are today known as Intrinsically Photosensitive Retinal Ganglion Cells containing melanopsin (ipRGCs) (Hattar et al., 2002), which are most sensitive to wavelengths of about 480 nm (Hankins et al., 2008). The discovery of ipRGCs and their spectrum of action has focused the industry attention on adding short-wavelength radiation to the light source spectrum, even during the daytime. Many discoveries have been made, such as the existence of specific structures in the retina called ipRGCs containing a photosensitive protein called Melanopsin (Provencio et al., 2000), which can carry out the phototransduction phenomenon (like the other photoreceptors, cones and rods). The difference is that the electrical impulse created by these cells follows a different pathway from that of vision and is channelled through the retina-hypothalamus tract, which will affect the pineal gland by suppressing melatonin. This hormone is responsible for the insurgence of drowsiness and is essential and the regulation of the human circadian cycle. These notions highlight a fundamental point: the influence of light and color on human physiology does not exactly follow the mechanisms of vision. This topic is a knot to unravel today as little has been done in this regard, especially regarding the overlapping or simultaneous execution of these two processes, which, although distinct, may not be mutually exclusive.

In this perspective, the literature on color psychology is full of articles where colors are often associated with characteristics such as hot, cold, etc. (Elliot, 2015). It is not uncommon for an individual to associate the term “activating” with warm, bright colors such as yellow and red, whereas, physiologically, activating colors are at the opposite end of the spectrum (blue). Furthermore, it is not uncommon for such colors to physiologically activate our heartbeat (Cajochen et al., 2005, Thompson et al., 2008), increase body temperature and affect the activity of the cerebral cortex (Badia et al., 1991). The doubt arises from these observations that a system as complex as human perception does not possess some form of convergence between these two mechanisms.

Discussion

The world is full of light stimuli that are often taken as objective and universal an emotional or physiological response humans feel related to any stimulus, whether it may be an object, a room, the scene of a movie, and so on; however, this is a highly deviant concept that stems from the way individuals see things and end up in underestimating them, a kind of bias. Studies on perceptual dysfunction in patients with perceptual disorders lead researchers to think that this process is not as objective as commonly believed but rather subjective, and studies on healthy individuals also support this. Therefore, it appears to be of fundamental importance to understand why people react to a light stimulus and how it triggers both an emotional and physiological response.

The idea of this research is to verify if there is a proportion in these two mechanisms: in the first moment, through an extensive analysis of the available bibliography and in the second moment, through tests on subjects. Going through the articles that describe what has been studied up to the present day, it is already clear that the common approaches of these two disciplines (physiology and psychology) have different analysis methods. As an example, while physiology generally measures the impact of the stimuli on the organism by the concentration of melatonin in the bloodstream or saliva or through ECG and EEG, the branch of psychology relies much more on visual tests done on subjects, with oral surveys (also eye movement, pupil size); two different approaches that need to be cross-referenced in some way, to avoid misinterpretation of the results.

It will be necessary to find a test approach that allows one to evaluate the two processes coherently, minimizing the visual bias that can emerge in the context of the psychological evaluation. To be able to obtain results that can be applied in the field of design, it will be desirable to resort to the use of mockups of real scenes rather than simple visual stimulation through displays or visors, precisely to avoid creating the abstract percept of a color sensation, which may not correspond to its application in a real context.

Conclusions

In this article we have discussed the early stages of research that aims to understand whether it is possible to find a proportion between the emotions and moods elicited by colors and their influence on our physiology.

To date, lighting devices that populate homes (smart bulbs or LED strips, perhaps controlled via apps) have chromatic routines that intend to influence the emotional state. However, the approach of these systems is to mimic the real world, attributing arbitrary definitions that can be more or less accepted by users (polar breeze, tropical sunset, winter bonfire, etc.).

Other lighting products aimed at achieving the so-called methodologies aimed at implementing the principles of human-centric lighting are mostly focused on achieving the well-being of individuals by intervening in the physiology (circadian rhythms) and optimizing the photometric performance as much as possible (distribution of luminous intensities, glare control), relegating the sphere of color once again to a mere aesthetic expedient.

The possibility that the two perceptual processes are correlated, and the way this happens or, on the contrary, that the two paths are mutually exclusive without having any direct interaction leaves room for exciting research that can lead to direct feedback in the design of products for the lighting that contribute to the well-being of individuals in an even more complete way than existing products.

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The value of colour in clinical diagnostic dilemmas

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Keywords: case study, colour vision assessment, CAD test, visual function loss, retinal dysfunction, pupillometry, contrast sensitivity

Background

The primary goal of clinical visual assessment is to obtain data to effectively guide management decisions. It may therefore be surprising that the assessment of colour discrimination, arguably the most sensitive attribute of vision[1,2], is often considered as a secondary measure. This is particularly true in challenging diagnostic dilemmas that do not fit into neat clinical boxes. Congenital colour vision deficiencies are inherited and often exist with the patient unaware, at least until they are assessed in a clinical or occupational setting. By contrast, acquired colour vision deficiencies can be highly symptomatic[3] and, unlike congenital deficiencies, acquired colour vision loss is often classified by the symptoms or the site of pathology[4]. As such, the diagnosis and swift identification of an acquired colour vision deficiency has a large potential benefit to clinicians and patients alike. We present a case involving localised retinal dysfunction that is not fully consistent with signs of either autoimmune retinopathy or occult maculopathy, highlighting the potential value of colour vision assessment when used in conjunction with standard diagnosis algorithms.

Methods

Central and peripheral red / green (RG) and yellow / blue (YB) colour vision were assessed in a 32-year-old with suspected central retinal dysfunction using the Colour Assessment and Diagnosis (CAD) test at City, University of London. The use of the CAD test for the purpose of assessing peripheral colour vision is a new and novel application and has not been described previously. The Advanced Vision and Optometric Tests (AVOT) were used to carry out additional measurements at City, University of London to assess and quantify mesopic visual acuity (VA), functional contrast sensitivity (FCS) and rod- and cone-mediated flicker sensitivity. Pupil responses were measured with the P-SCAN 100 system[5] using both rod- and cone-enhanced stimuli.

Results

Central colour vision assessment using the CAD test showed severe RG and YB loss, however outside the central 10° field the patient had almost normal colour and spatial vision. A sample of the CAD results shown in Figure 1 expose the difference between the patient's central and peripheral colour vision for 'green' colours shown on a background of dynamic luminance contrast noise[6]. As shown in Figure 1, when presented centrally the median chromatic signal strength required was approximately 40 times larger than the signal strength required in a normal trichromat. When presented in the periphery the median chromatic signal required was approximately 1.3 times larger than the signal strength required for a normal trichromat.

The AVOT results revealed a loss of VA and FCS in the central 10° field, although both VA and FCS were less affected with negative contrast stimuli and depended strongly on light level. Rod- and

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cone-mediated, flicker thresholds were elevated, with cone thresholds 10-fold higher than normal. Pre-stimulus pupil size, constriction amplitudes and latencies were normal with both centrally presented and peripheral stimuli.

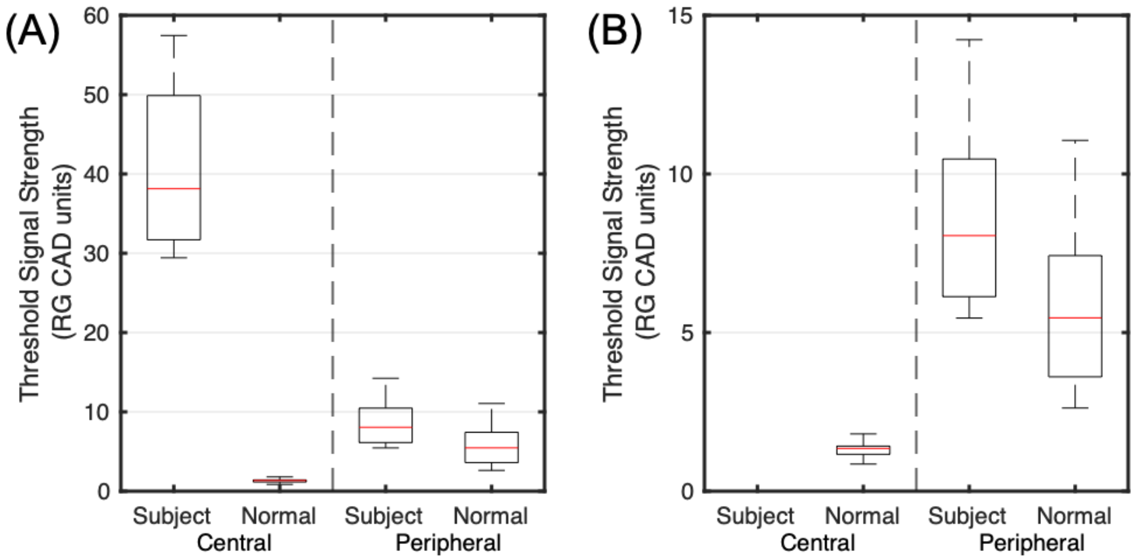

Figure 4: Colour thresholds measured centrally and peripherally using 'green' colours in a normal trichromat and a patient with localised retinal dysfunction. (A) and (B) show the same data with a different vertical scaling.

Conclusions

Colour discrimination can provide unique and valuable clinical data, particularly when used in conjunction with a standard array of diagnostic tests. The use of colour vision assessment and its potential role in guiding patient management decisions is an exciting area that has yet to be fully utilised.

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5. Color and Production

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Colour fading of aged knitted materials for swimsuits

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Abstract

Textile materials for production of swimsuits are knitted. The characteristics of this type of fabric are durability, chlorine resistance, and comfort. In this paper, the properties of knitted fabrics from well - known manufacturers are examined. Nine different knitted fabrics intended for the production of swimwear are exposed to aging in seawater and chlorinated water, and the influence of the sun for 100 hours. The tested materials are made in a blend of polyamide and elastane fibers in different percentages. Change in color after aging was observed, and the results are presented as differences in CIELAB color parameters and total color differences. After exposure to aging conditions, it is observed that samples exposed to aging in the sea have a greater or approximately equal total difference in color from samples exposed to the same number of hours in chlorinated water. The average dE for samples aged 100 hours in the sun, in seawater, is 2,212, while the dE for samples aged the same number of hours, in the sun, in chlorinated water is 1,374.

Keywords: knitted fabric, swimsuits, polyamide, colour fading, outdoor weathering.

Introduction

The production of swimwear began in the early 20th century, and the first manufacturers were companies that until then produced knitted underwear. The materials for swimwear are all knitted and represent a very small percentage of the total production of knitwear. In recent years, research into this type of knitting has developed in various directions, and investments have been made in improving the properties of materials for swimwear. The properties and construction characteristics of knitwear for swimwear depend primarily on the requirements of the target group. They can be divided into competition, training and fashion swimwear. Competition swimwear is a special type of material with increased performance. Example of raw material composition for competition swimwear: 65% PA / 34% EL / 1% carbon. Carbon fibers form a strong network, and the parts have a special construction of seams and pressure plates (Potočić Matković et. al., 2021). These professional suits usually contain targeted, structured knit zones to support specific muscle groups. Swimwear for sports is usually made of a mixture of polyamide and elastin, and often 100% polyester fibers. Today, recycled materials are becoming more popular, so sports swimwears are now made from recycled polyester or polyamide. Flexibility, comfort, quick drying, high chlorine resistance and durability are the characteristics of this type of knitted fabric with emphasis on speed and hydrodynamics. Low water absorption is also desirable, reducing resistance to body movement in the water. Sufficient compressibility and elasticity in all directions to support muscles. Unlike sports swimwear, the fashion emphasis is on comfort, quick drying and easy care. Some of the most common compositions are 80% PA /20% EL, 83%/ PA /17% EL, 90% PA /10% EL, 85% PA /15% EL, 82% PES /18% EL. In this category, the main focus is on esthetics, color, print and decorative details (Omerović et. al., 2022).

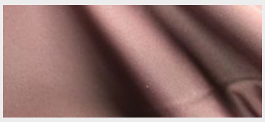
Polyesters and polyamides are manufactured in a very similar manner and have similar thermoplastic properties, lower water absorption and higher dimensional stability. However, absorption of UV rays causes chain scission in the polymer (McKeen, L.W., 2013). Numerous studies have shown that exposure to weathering significantly affects the decomposition of polyamide, polyester and elastane at the molecular level, which in turn affects the material properties(Čubrić et. al., 2021). The changes in these properties also affect the comfort and durability of the material. According to the study by Salopek Čubrić et al (2021), a protocol for the aging of materials in swimming pools was developed based on the number of training sessions of athletes and the continued use of the same materials. The aim of this protocol is to analyze the effects of aging on material properties. Chlorinated water, perspiration in an aqueous medium and in dry conditions, and maintenance and care of swimwear after each workout are cited as the most important factors in the aging of swimwear. In the summer months, UV radiation and air temperature are important factors in aging swimwear when it comes to outdoor training. Seawater, along with UV radiation and air temperature, is another aging factor that was considered in this research to mimic the natural aging of materials as closely as possible.

For materials exposed to aging, the consumer first notices a change in the appearance of the item, such as a change in color and mechanical properties. A lot of research has been done on textile discoloration, and a variety of color pigment paste dispersions are available for use on textiles. The need to increase weathering resistance and durability of materials has encouraged the development of colored polymer dispersions (Potočić Matković et. al., 2021). The color change of textile products, i.e., the evaluation of color fastness, can be visually tested using a gray scale according to the HRN EN 20105-A02 standard. The gray scale for evaluating color change is a subjective method. The scale contains five levels or five color pairs representing the color difference. The levels correspond to values from 1 to 5 and consist of two color parts. The first part is neutral (dark gray) and the second part changes, i.e. it gradually becomes lighter. The evaluation of the color change between the standard and the sample according to the gray scale is not completely objective, because it is visual and depends on the psychophysical characteristics of the examiner. Objective evaluation is achieved by instrumental spectrophotometric measurements. In this work, the objective CIELAB method is used to measure color change, where color is measured in a three-dimensional system (L*, a*, b*) with a colorimeter. This paper examines the influence of natural weather conditions on the color fading of sports swimwear materials. The research also aims to compare the construction characteristics of swimwear knits and color fastness under the influence of natural weather conditions.

Materials and structural properties

Nine different fabrics intended for the production of swimming suits were examined. The samples were selected according to the criteria of the most common raw materials for fashion and training costumes in different colors. The physical and mechanical properties of all knitted fabrics were tested before aging. Table 1 shows the measurement results for the knitted fabrics before aging. Surface mass, thickness and knit density were tested. The manufacturer states in the product description that all knitted fabrics are chlorine resistant, durable, mildew resistant and have UV protection. According to the raw material composition, they are all a mixture of polymer and elastane in different proportions.

Table 1 : Properties of the tested swimwear fabrics

	Photograph	Fibre composition	Mass per unit area, g/m²	Thickness, mm	Density per cm horizontal / vertical
S1		80% PA 20% EL	187,84	0,655	46/26
S2		80% PA 20% EL	171,75	0,655	42/26

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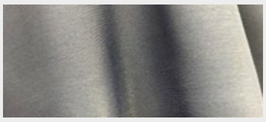
S3		78% PA 22% EL	198,13	0,561	44/26
S4		78% PES 22% EL	209,59	0,527	42/25
S5		59% PA 41% EL	226,46	0,495	26/24
S6		73% PA 27% EL	113,11	0,358	28/26
S7		80% PA 20% EL	216,52	0,502	20/24
S8		72% PA 28% EL	160,97	0,404	28/26
S9		71% PA 29% EL	184,10	0,450	26/20

Measuring methods

A Dino-Lite Pro AM7000 microscope at 200x magnification was used to measure the horizontal and vertical density of the knitted fabric to one centimeter. According to the standard ISO 3801, method 5, the mass per unit area of the knitted fabric was measured. A cut circular sample with a diameter of 10 cm was measured on an analytical balance with an accuracy of +/- 0,001 g. A pressure of 1 kPa was used when testing the thickness of the knitted fabric, and the test was performed in accordance with the standard EN ISO 5084: 1996. The distance between the reference plate, on which the sample was placed, and parallel circular feet and the measured results were expressed in mm.

Accelerated aging was performed under conditions that mimic the natural aging of materials. Specimens were immersed in seawater and exposed to sunlight for 100 hours. The test was conducted in Dubrovnik, Croatia, during the summer from 10.08. 2021, to 14.08. 2021. A new aging cycle of 100 hours of soaking in chlorinated water exposed to weather conditions was performed in Zagreb, Croatia, from 15.09. to 20.09.2021. After soaking, the samples were washed ten times in a washing machine at a temperature of 30°C for 20 minutes with a centrifuge at 800 rpm. A detergent (ECE Formulation Non-Phosphate Reference Detergent, Without Optical Brightener) was used to wash the samples. They were all air dried in the shade. The known metrological conditions during the study period are listed in Table 2.

Table 2: The climatic conditions during the test

	Dubrovnik- August					Zagreb- September					
	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Temperature -t- monthly mean of daily mean (°C)	31	32,5	34,1	33,4	34,4	32,2	28,7	22,5	21,9	21,5	17,3
Precipitation - R - monthly total ofrainfall (mm)	0	0	0	0	0	0	0	1,3	10,3		15,8
Relative humidity - Rh - monthly meanof daily mean (%)	61	47	46	49	46	51	58	90	77	77	79

The color characteristics of the sample was evaluated using the DataColor Spectra Flash 600 PLUS - CT emission spectrophotometer. Five measurements were taken from each sample, using the LAV measurement area of 26 mm. The results are presented as total color difference values (dECIE76) obtained by measuring and comparing the samples before and after aging. Colour difference values were calculated using formula (1), defining the samples before exposure as reference samples.

dECIE76 = ((dL*)2+(da*)2+(db)2)1/2 (1)

where dL* is difference in lightness value, da* and db* are differences in a* and b* colour coordinates indicating the change in L* a* b* colour space position and also indicating the change in chroma (C*) and hue (h).

Results and Discussion

The results of measuring the surface mass and thickness of nine selected samples after the aging process are shown in Table 3. After aging in chlorinated water, the surface mass and thickness of the sample increase for most of the substances, except for sample S1, which shows a slight decrease in mass of 2,07 g and sample S4 with a decrease in thickness of 0,004 mm. The results of aging the samples in seawater show the same trend, with the surface mass and thickness also increasing for most samples. The results show that the least change in thickness and mass is observed in sample S5 with the highest elastane content of 59% PA 41% EA, which gives it very good dimensional stability. (Table. 3.)

Table 3: Change in surface mass and thickness after the aging process.

	Mass per unit area, g/m2	**Thickness, mm**	**Mass per unit area, g/m2**	**Thickness, mm**
	Chlorinated water		Sea water	
S1	185,77	0,676	191,35	0,680
S2	180,04	0,673	183,89	0,674
S3	204,06	0,563	207,00	0,569
S4	199,69	0,523-	203,62	0,518
S5	224,09	0,499	224,45	0,497
S6	120,89	0,368	112,87	0,351

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S7	223,23	0,512	239,16	0,521
S8	167,93	0,414	173,35	0,411
S9	186,58	0,459	188,72	0,466

The color change test on a spectrophotometer gives results for the total deviation, i.e. the total color difference between the standard and the sample. The difference in color depth dL*, where positive values indicate lightening of color and negative values indicate darkening. Then da*, which represents the changes on the red-green axis, db* the difference on the yellow-blue axis, dC* the color deviation and dh the total hue deviation. The instrument also allows these ratings to be compared to grayscale ratings. From the table 4, it can be seen that the color changed for all samples, but for some samples the change is within the tolerance limits for textile materials. The greatest color change was found in sample S4, which was also confirmed with a grayscale rating of 2-3.

Table 4: Change in color of samples after aging in chlorinated water.

Samples	**dL***	**da***	**db***	**dC***	**dh**	**dE**	**Gray Scale for Color Change Rating**
	Chlorinated water						
S1	-1,28	-1,84	0,55	-1,45	1,26	2,31	4
S2	0,99	0,08	0,2	0,12	0,18	1,02	4-5
S3	-0,3	0,23	-0,09	0,25	0	0,39	5
S4	-3,41	3,11	-0,01	1,23	2,86	4,62	2-3
S5	-0,01	0,15	0,03	-0,02	0,15	0,15	5
S6	1,08	0,3	-0,67	0,71	0,19	1,3	4-5
S7	-0,61	0,22	-0,09	0,13	0,2	0,65	4-5
S8	-0,25	-0,64	1,32	-1,24	-0,77	1,49	4-5
S9	0,27	0,07	-0,33	0,34	-0,02	0,44	5

The following table 5 shows the results of the color change that occurred after the knitted fabric was immersed in sea water and exposed to the sun for 100 hours. The results show the same trend of color change with slightly higher results for individual samples. And this measurement showed that S4, S1 and S8 are the samples with the highest values of color change after aging. Also the displayed gray level values confirm smaller values, i.e. larger color changes.

Table 5: Change in color of samples after aging in sea water.

Samples	**dL***	**da***	**db***	**dC***	**dh**	**dE**	**Gray Scale for Color Change Rating**
	Sea water						
S1	-2,04	-3,3	-0,06	-3,03	1,32	3,88	3-4
S2	0,1	0,12	0,09	0,13	0,06	0,18	5
S3	-0,17	0,13	-0,1	0,16	-0,05	0,23	5
S4	-5,17	3,25	1,47	0,04	3,57	6,28	2
S5	2,05	-0,07	0,23	-0,24	-0,05	2,06	4
S6	1,96	0,08	-0,92	0,92	-0,06	2,17	4
S7	-0,43	0,37	-0,78	0,84	0,22	0,97	4-5
S8	1,92	-2,26	1,87	-1,56	-2,48	3,5	3-4
S9	0,53	-0,19	-0,3	0,23	-0,27	0,64	4-5

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Conclusions

In the present work, nine different knitted fabrics for fashion and/or swimwear were examined for their formation and color change after defined aging conditions. All knitted fabrics consist of polyamide and elastin in different proportions, with the exception of sample S1, which consists of polyester/elastin. The aging conditions performed in two cycles show the same tendency to color change. From the test results, it can be seen that the greatest color change in both cycles is in raw material composition S4 (polyester/elastin), which is also the only white sample. The gray scale results also show that this sample has a color change grade of 2 after aging in seawater and a slightly better grade of 2-3 after 100 hours of soaking in chlorinated water.

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6. Color and Restoration

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A piece of New Zealand Heritage: Colour Design and Conservation of Grey Lynn Library

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Abstract
The Grey Lynn Library in Auckland, New Zealand (opened in 1924) is one of the small treasures of Gummer and Ford's architectural output, incorporating its graciously high steel framed windows, fabulous volumes entirely suited for browsing and reading library books. The goal of this research is to reveal the significance of this small architectural gem within the 'minor' Architectural heritage of New Zealand and to outline a proposal for the conservation of its colours in the near future. The methodology of the study involved literature review and archival research as well as on-site analyses. The latter involve the identification of the building colour palette (façade and interiors). The results include a brief guideline for future conservation of the building.

Keywords: New Zealand Heritage; Colour conservation; Cultural heritage

Introduction

Architect William Gummer (1884-1966) was born in Auckland, New Zealand. He left for the United Kingdom in 1908, studying at the Royal Academy of Arts in London, and later qualified as an associate of the Royal Institute of British Architects. He notably worked for Sir Edwin Lutyens (and Daniel Burnham of Chicago). Upon his return home he set up the architectural practice "Gummer Ford" in 1923, (with Englishman C.R. Ford, who had travelled as the youngest member of Scott's Antarctica 1901-04 expedition). The practice produced notable buildings in Auckland, firstly in the Beaux Arts and later in Modernist idioms. One small treasure is the Grey Lynn Library (opened in 1924) with its high gracious steel framed windows that activate the two reading spaces. Although the building is currently a little faded in terms of surface decoration it retains its fabulous volumes still entirely suited for browsing and reading library books.

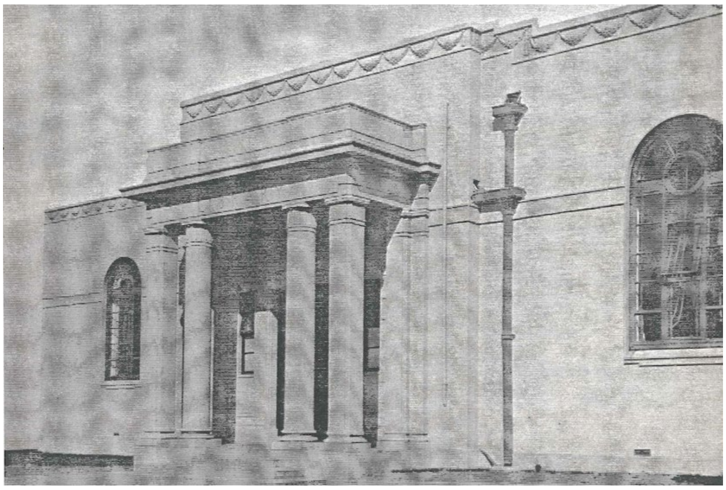

Fig. 1 – Grey Lynn Public Library - Exterior, c1924
Unknown photographer

Fig. 2 – Grey Lynn Public Library – Exterior, 04.08.2022
Photo by Author.

The Grey Lynn Library is situated at 474 Great North Road, Grey Lynn, Auckland, New Zealand, and "is now the oldest purpose-built library still operating in Auckland," (Barrie & Gatley, 2007). As can been seen comparing the above original black and white image and today's colour image, (Figures 1 and 2), the building still retains its modest nobility as a civic building. Accepting the intervening passage of time (98 years), the interiors have been altered, Wi-Fi, and computers added to keep such a library 'up with the times.'

Fig. 3 – Grey Lynn Public Library – North Reading Room Interior, 04.08.2022
Photo by Author

As members of Auckland Public library service, the authors note, that belonging to the City's Library remains free, this Grey Lynn branch is just one of 56 libraries, (these stretch over the 4,894 sq.km of the Hauraki Gulf, and includes two libraries on outlying islands, and additionally incorporates Mobile Bus Libraries that serve various outlying communities). With the computerization linking all these branches it is possible to reserve a book and have it couriered to your local branch (again at no cost to the borrower). Before 2010, (when the seven separate councils were merged into one so called 'SuperCity'), Julian had to borrow his father-in-law's library card and drive across the harbour bridge to a particular Library to be able to take out a book from any of the North Shore branches. In addition, the Auckland Library's free Wi-Fi service have made library forecourt spaces socially popular with many (particular young) people today, with people often seen sitting on bench seats glued to their mobile devices at all times of the night and day.

This library building itself stands on a sweeping 120-degree corner of Great North Road, with the St. Joseph's Catholic Church adjacent. With Auckland still being a car-oriented city, most people are concentrating on negotiating this curve as they drive, and thus one can easily just drive past and not notice the building's narrow northern flank that affronts the road. There are the bus stops just 100 metres away at the Grey Lynn Shops, so one can walk easily to and from the library, (even if carrying a bag full of books). The library's entry portico is around to the right (West facing facade), with its square corner columns (and pilasters at building face), paired a pair of round columns that welcome the visitor as one ascends the five steps to the vestibule. The entry space is rather tight, (by modern library design standards), this is obviously a deliberate architectural squeezing of space before bursting into the 5.36-metre-high central space, (which now holds the front issuing desk, photocopier, and self-issuing scanning machines). This large central volume is surprisingly light filled, (via 1.6-metre-high laylights: seven to the east and five to the west), these provide raking morning and afternoon light deep into the interior and allow glimpses to the sky and weather from inside this heavy-looking building. Note from Figure 2, how the West facing five laylights are completely and cleverly hidden by the Entry portico parapet, and if the reader checks *Google Earth*, you will see that the West facing laylights are in fact tucked in the roof deck behind the portico and the East facing ones are hidden by the 1962 addition. Making this interior lighting surprise complete. This main space is flanked to each side by the 4.51-metre-high North and South reading rooms. Both reading rooms contain 1.7-metre-high shelving units for books around walls and 1.4-metre-high double backed island shelving units so library visitors can view with ease, (Figure 3, above). The North reading room has three arched window openings, (two to the West and one to the North). Similarly, the South reading room has the same arched windows, except there are two facing west and two facing east. These arched windows are steel framed with single glazing, (the window dimensions being: 2.85-metre-high x 1.58-metre-wide and the sill is 1.50-metre-above floor level). These large windows also contain hopper-type openings at low level for ventilation, (Figure 3, above). The Library's South wall abuts the adjacent 'Community Hall,' (the historical plan labelled this as a 'Lecture hall') and is blank except for a single door to a toilet, and which now provides no access to the Stage versus what is shown on the historical plan. Returning back towards the entry doors, one notices how tight the entry really is, which is two flanking recesses (1.6-metre-wide, refer to Figure 4, below), this width is currently further lessened by the bookshelves holding inter-loan books awaiting pickup.

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Fig. 4 – Grey Lynn Public Library – Interior of south recess adjacent Entry 04.08.2022
Photo by Author

Research Methodology

The methodology of the study involved literature review and archival research, (historic photos, drawings and other material provided by the local Council), as well as on-site analyses. The latter involved the identification of the building colour palette (façade and interiors). To establish the colour palette of the building a field study was carried out, using the "Natural Colour System (NCS)" which is the colour model most used by professionals in this field. Surface colours were detected by pressing the NCS Colourpin SE tool directly against each surface and reading the possible matches on the Colourpin software on an adjacent digital device. The colours have been tabulated via the NCS 1950 chart and the relative RGB values directly from the Colourpin software (Figures. 5, 6, & 7). Colours identified have been compared with archive material related to the building (photos and drawings) to understand if any modification occurred over the years. In particular, two theses at the University of Auckland and the 'Property File' obtained from the Auckland Council have been useful in this part of the research. The process included an historical contextualisation of the current colours, to match them with a particular architectural style of New Zealand. The closest match was with Art Deco colours. Hence, the current palette has been compared with typical palettes of New Zealand Art Deco architecture to better understand colour choices. These palettes were found in the website of the most prominent local paint manufacturer (Resene). It should be noted that the so called 'Art Deco style' was primarily introduced to New Zealand after the 1931 Napier earthquake which flattened a lot of brick buildings in the city centre. Those buildings were replaced with new versions largely designed by Californian architects who travelled out here in search of new work as a result of the global economic recession of the 1930's. This led the authors to develop a set of suppositions regarding the possible original colour aspect of the building (which may differ from the current one), our hypothesis is also based on the contemporary production of Gummer and Ford.

Results and discussion

The Grey Lynn Library's colours identified appear to be in the range adopted in other buildings of the Beaux Arts and Art Deco style in New Zealand. This building - in its current state - probably represents a transition between the two styles. Obviously, we could not scratch walls' surfaces to investigate the original colours (if still present), hence we based our study on the current colours and on the information available from the literature and other 'Gummer Ford' work. In New

Zealand, the most relevant case studies of Art Deco buildings can be found in Napier. However, as mentioned before, those Art Deco buildings were built in the 1930s. In that period, pastels and clear brights 'were a welcome escape from the dreariness of the depression' (Resene, 2022). When applied to building exteriors these were typically used as accents, often in contrasting colours, picking out the Art Deco detailing and patterning, against walls of white, off-whites, creams, or pale pastels. This is the current case of Grey Lynn Library where the portico is beige, the fascia's and cornice are yellow and window frames are blue, while the external walls are cream white (Figure 5). The yellow cornice is characterized by a moulded repetitive pattern that surrounds the whole building. The Entry doors are of a cold white and this seems uncommon for this architectural style, however, they add to the sober look of the finished structure. Historical black and white photos, (as the one published in Shanahan, 1983) show the Lecture Hall entry door in a darker colour. A similar view, (taken in 1983?), shows part of the main façade (north-west) covered by climbing plants. In another photo of 1996, included in the Council's Property File, the Lecture Hall door was painted green as were the downpipes; (and the window frames look darker than the current colour). In a yet another photo of 2009, the library main entry door was painted blue, as well as the downpipes. The roof is covered in terracotta tiles and has a peaked roof vent, capped by a weathervane in an American style. Unfortunately, we were not able to find information about the original colours adopted in 1924. Also, we are not sure if the black and white photo (Figure 1, dated 1923 by Bruce Petry) really belongs to that period (Petry, 1992). The authors' would like to point out the following information that was obtained from the 'Council's Property File':

- The Building was built in 1924;
- The Windows have been replaced in 1959;
- The south-east extension was designed in 1962;
- The extension to the Lecture Hall and the ramp were designed in 1980;
- The entry ramp and balustrade were modified in 2009.

Further: the structure of the building is a reinforced concrete frame with cavity brick infill. The inside has been solid plaster rendered, but the outside was left exposed and painted in white, (Shanahan, 1983). This is different from the buildings in Napier where the facades were plastered. In the north-west façade we have found traces of a blue background behind the exterior white. We could not identify any reason for that. And, part of the south-west façade has been protected with a greyish paint, probably to hide spray-paint vandalism. The extension on the south-east side (1962) is clad with dark red bricks, which have still been left exposed.

In New Zealand Art Deco architecture, interior colours are usually pale with pastels being common. White walls were not pure white but tended to be a soft or biscuit cream, to contrast the prevalence of soft pastels. Within the Grey Lynn Library, the interior walls are light pink-white (S 0505-Y80R) contrasted by the pink window cornice (Figure 6). Gold was a popular metallic of choice for furniture and décor (Resene, 2022). In both reading rooms we can still see a golden strip just below the ceiling. The same golden strip is present also in the two walls of the vestibule as a simple decorative motif. In the Lecture Hall, the grid of ceiling beams has been emphasized by boxing the beams in with varnished wood (Shanahan, 1983), (refer also to Figure 7).

	NCS 1950	RGB	ELEMENTS
FACADES	S 4005-G80Y	152, 150, 133	CONCRETE BASE
FACADES	S 3000-N	178, 176, 174	IRON BALUSTRADE
FACADES	S 0603-Y20R	241, 234, 218	WALLS
FACADES	S 3010-Y30R	187, 164, 139	COLUMNS / WINDOW SILL / MEDALLION
FACADES	S 1515-Y10R	221, 201, 160	FASCIAE
FACADES	S 6020-B	58, 87, 104	DOWNPIPE / WINDOW FRAME
FACADES	S 4030-Y60R	167, 105, 79	BRICK WALL (EXTENSION)
DOORS	S 0603-G80Y	238, 235, 222	MAIN ENTRY DOOR
DOORS	S 0502-Y	246, 240, 228	DOOR TO HALL

Fig. 5 – Main façade and its colours
Photo by Author

	NCS 1950	RGB	ELEMENTS
MAIN ROOMS	S 3050-Y30R	192, 122, 58	ENTRY DOOR
MAIN ROOMS	S 6005-Y80R	119, 106, 102	ENTRY LINOLEUM
MAIN ROOMS	S 7502-B	74, 76, 78	CARPET
MAIN ROOMS	S 5030-Y50R	144, 90, 62	TIMBER SKIRTING
MAIN ROOMS	S 0505-Y80R	247, 232, 224	WALLS
MAIN ROOMS	S 1015-Y80R	238, 197, 186	WINDOW CORNICE
MAIN ROOMS	S 4020-B	100, 132, 148	WINDOW FRAME
MAIN ROOMS	S 4010-Y50R	169, 145, 128	GOLDEN STRIP
MAIN ROOMS	S 0502-Y	246, 240, 228	CEILING PANES
MAIN ROOMS	S 0505-Y80R	247, 232, 224	CEILING FRAME

Fig. 6 – South reading room views
Photo by Author

	NCS 1950	RGB	ELEMENTS
LECTURE HALL	S 4050-Y50R	158, 82, 38	ENTRY DOOR
LECTURE HALL	S 3040-Y40R	193, 125, 76	TIMBER FLOORING
LECTURE HALL	S 6030-Y70R	111, 54, 35	TIMBER SKIRTING
LECTURE HALL	S 0505-Y90R	247, 232, 226	WALLS
LECTURE HALL	S 6030-Y70R	111, 54, 35	CEILING STRUCTURE
LECTURE HALL	S 0505-Y90R	247, 232, 226	CEILING PANES

Fig. 7 – Lecture Hall and its colours
Photo by Author

Comparison with other buildings designed by Gummer and Ford

Arden Lodge in Havelock North (Hawke's Bay), a building currently protected by a 'Category 1' historical listing and designed by Gummer and Ford, was restored in 2006. Built in 1926 (only two years after the Grey Lynn library) it was constructed of reinforced concrete and brick with a cavity wall stucco exterior. The exterior paint finish (probably similar to the current version of the library) has been replaced with a Resene weathertight acrylic coating (Resene, 2006). The selected colour was 'Resene Double Pearl Lusta' (warm cream), that was aligned with the colour palette of that time, and from the photos, similar to the current exterior walls of the Grey Lynn library. The walls creamy finish was complemented by 'Resene Lumbersider' satin acrylic tinted to 'Resene Canterbury Clay' (muted French beige) on shutters, similar to the current portico of the library.

Although the Grey Lynn Library is one of the earliest works of the architectural practice Gummer and Ford, would also point out that Gummer Ford's Remuera Public Library was completed just two years after Grey Lynn's: in 1926, (Barrie & Gatley, 2007). There are some noteworthy similarities between the two libraries viz. similar spatial planning of both facilities: the Reading Rooms flank both sides of a similar Entry portico, and there is also a rear Lecture Hall to each complex. And the interior ceiling panelling to both reading rooms and lecture halls respectively are remarkably similar.

Fig. 8 – Remuera Public Library – Main Façade facing Remuera Road, 28.08.2022
Photo by Author

However, there are also some differences, mainly due to the site context of the latter building on a straight stretch of Remuera Road, the building's reading rooms and portico face broadside to the main road, (versus Grey Lynn's being side on to the road); and the Remuera Lecture Room has its own entrance off a side street to the West, (via St. Vincent Avenue). Both Libraries are brick clad, Grey Lynn's brickwork cladding being over painted; whereas the Remuera Library has exposed facing bricks to the reading/lecture rooms, (refer Figure 8). Both libraries have solid-plaster finished entry portico, columns and pediments suggesting the possibility that Grey Lynn's were also originally unpainted. And thus it may well be that the Grey Lynn Library was only painted later on, and as analysed by this paper possibly in the Art Deco style emanating from the 1930's.

Final remarks relating to the Colours

Beside maintaining the current colour palette for the interiors and for the facades, we would recommend reviewing the colours of the main entry doors. To be consistent with the current colour style, this also seems to be closer to Art Deco, we recommend replacing the current colour of the doors with the one of the indoor window frames (S 4020-B) which seems to be coherent with the photos of 1980s.

Conclusions

The identified colour palette captures the current colours of the building, which seem to be aligned with the typical palettes of Art Deco buildings in New Zealand. However, if compared with Napier colours (1930s), this building looks more sober with its pale pastels and cream white walls. We also discovered the building has been altered over the years. And the colours of the entry doors have been changed multiple times. Probably, the colour of the window frames have also been changed. Our site research and Colourpin analysis of final colour palette should be useful to practitioners in regard to any future conservation. Without resorting to damage via ‘paint scrapings’, this paper attempts to highlight one small gem of early New Zealand’s 20th Century architecture.

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Colorimetric and spectroscopic analysis of a 19th-century impressionist painting with reflectance hyperspectral imaging.

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Abstract

Reflectance hyperspectral imaging (HSI) is a diagnostic technique used for the study of cultural heritage objects. This technique allows the acquisition of hundreds of images in narrow contiguous spectral bands - in the visible (400-750 nm) and near infrared (750-2500 nm) regions - resulting in a data set called "cube-file" (also "image cube file"). These data provide different types of information: two dimensions of the cube-file contain the spatial information, while the third dimension contains the spectral ones. This allows each pixel of the image to be associated with a reflectance spectrum. Therefore, it is possible to identify artists' materials and their distribution in a work of art. Furthermore, it is possible to obtain colorimetric data from these spectra using the calculation procedures defined by the International Commission on Illumination (CIE) if the HSI data were acquired with measurement geometries recommended by the CIE.

This contribution focuses on the analysis of hyperspectral data acquired with the system designed at the "Nello Carrara" Institute of Applied Physics of a 19th century painting signed by Édouard Manet. Starting from the acquired cube-file, the aim of this work is to highlight the connection between the colors and their different shades used by the artist and their colorimetric values calculated from their reflectance spectra. The final focus of this research activity is to connect the materials used by the artist to the shades of hues in the painting.

Keywords: hyperspectral imaging, colorimetry, reflectance imaging spectroscopy, easel painting.

Introduction

Reflectance hyperspectral imaging (HSI) is a non-invasive technique increasingly employed in the field of art conservation science. Originally developed for remote sensing and astrophysics, HSI systems allow to acquire hundreds of images in narrow contiguous spectral bands (bandwidth <10 nm), usually in the visible and near infrared regions (Vis 400-750 nm, NIR 750-2500 nm) (Verhoeven, 2018). All these images form a tridimensional data set known as "cube-file", in which two dimensions are associated to the spatial information (x and y coordinates) and the third to the spectral one (wavelength, λ). Hence, this allows to extract from the cube-file an image for every spectral band – or spectral range – that shows potential underdrawings, *pentimenti*, restorations, damages, or other hidden details. In addition, it is possible to obtain a reflectance spectrum for each pixel in the considered spectral region, which – theoretically – permits to identify the materials used by artists and their spatial distribution. Moreover, it is possible to get colorimetric information from the hyperspectral data following the calculation procedures provided by the International Commission on Illumination (CIE). These colorimetric values can be obtained only if the measurement geometry follows the CIE recommendations. All these possibilities make HSI a powerful and versatile tool in the non-invasive investigation and documentation of different types of artworks (Cucci, et al., 2016) (Picollo, et al., 2020) (Striova, et al., 2020). In fact, both reflectance spectroscopy and colorimetry are useful non-invasive methodologies to analyze artistic materials, usually employed in multidisciplinary studies of paintings or other works of art (Bacci, 2000) (De la Roja, et al., 2007) (Lorusso, et al., 2007) (Gil, et al., 2014). With HSI it is possible to carry on these analyses with one instrument. In a recent work (Martinez, et al., 2020), HSI was used

to determine the best consolidant for medieval plasterworks from a colorimetric point of view, by obtaining the information about color from the HSI data.
Instead, in the following study the colorimetric data are supported by the reflectance spectra to study the pigments employed in a painting. In particular, this work proposes the analyses carried out with the HSI system designed at the "Nello Carrara" Institute of Applied Physics (Florence, Italy) on an easel painting signed by Édouard Manet (Fig. 1). This painting represents a floral composition and dates back to the 19th century, in the impressionist period.
It was possible to calculate the values of the colorimetric coordinates in the CIE L*a*b* 1976 color space – from the acquired cube-files – for the different areas of color and to make the first considerations about the hues and the shades used by the artist. Secondly, reflectance spectra were obtained and analyzed in order to tentatively identify the artist's color palette. Given the results of the study, the aim of this work is to compare and connect the shades of hue to the employed materials to highlight the colorimetric difference between different pigments.

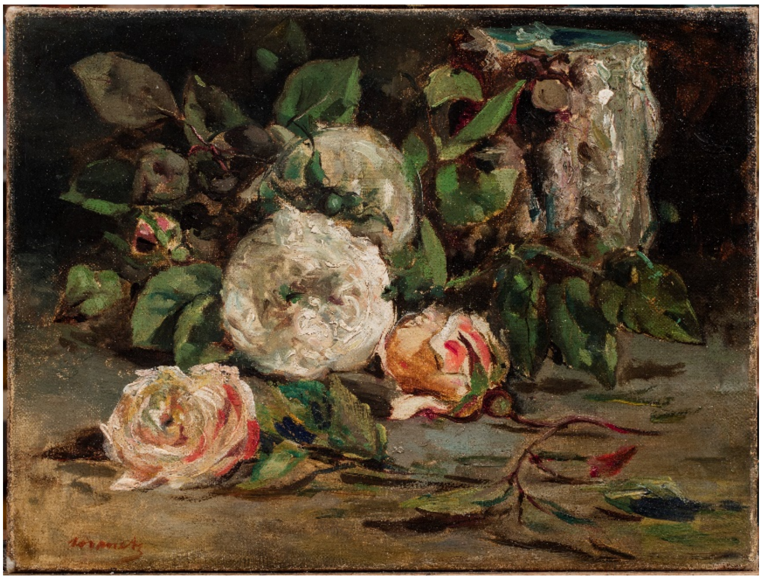

Fig. 1 – the analyzed 19th century painting signed by Édouard Manet

Method
Experimental
The following HSI data were acquired using the system developed at IFAC-CNR, equipped with two hyperspectral heads alternatively mounted on a mechanical structure for pushbroom scanning. The first one operates in the visible and near-infrared spectral regions (VNIR, 400-900 nm) with a telecentric objective (Opto-Engineering Srl) and a prism-grating-prism line-spectrograph (PGP, Specim ImSpector™ mod. V10E) connected to a digital camera Hamamatsu CCD ORCA-ERG (Cucci, et al., 2011). Instead, the second head works in the short-wave infrared (SWIR 950-1650 nm), with a telecentric objective, a PGP line spectrograph (Specim ImSpector™ mod. N17E) and a digital camera (Xenics® mod. Xeva 1.7-640) with an InGaAs array (Cucci, et al., 2013).
The illumination module is composed of two fiber optic illuminators which convey the radiation of a Quartz Tungsten Halogen lamp (QTH, 150 W, 3200 K) with a thermal filter for visible measurements, replaced with a filter that blocks Vis radiation during measurements with the SWIR head. These are fixed to the scan-head so as they light the painting with an angle of 45°: this results in a 45°/0° illumination/observation geometry, suitable for colorimetric analysis.
The spatial sampling is 11.4 points/mm in the VNIR setup and 9.2 points/mm in the SWIR region. At the end of the measurements two cube-files are obtained: the VNIR cube is composed of 400 bands with spectral sampling of 1.25 nm and a spectral resolution of 2.5 nm; the SWIR cube has 332 bands, with spectral sampling of 2.1 nm and a spectral resolution of 6 nm.

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The reflectance spectra were firstly visualized using ENVI® – a software for hyperspectral images processing and analysis – then saved as .txt files and processed with Origin 6.0, a graphing and data analysis software.
Since ENVI® does not provide modules for colorimetric calculations from the hyperspectral images, some programs have been developed at IFAC, which extract colorimetric images from the hyperspectral ones. The colorimetric images report the L*, a*, b* values for the *CIE 1931 2° Standard Observer* with illuminant D65 as separated floating point TIFF images, which can be displayed and analyzed by means of several image processing packages, even free as Fiji – ImageJ.

Results
The first approach in the analysis of HSI data was to obtain the L*a*b* values for different areas of color and to compare them (Fig. 2). Subsequently, reflectance spectra were extracted from the cubes (from an area of 5×5 pixels, 0,44×0,44 mm for the VNIR cube and 0,55×0,55 mm for the SWIR cube) and analyzed to identify the materials. The values of the colorimetric coordinates divided according to the material are shown in Table 1.

Table 1 – CIE L*a*b* 1976 values for each point and their pigment attribution

POINT	L*	a*	b*	PIGMENT
1	80.82	0.18	21.64	Lead white
1.1	85.44	2.09	18.53	“
1.2	76.61	-1.21	30.17	“
1.3	69.64	5.06	23.66	“
2	74.23	2.79	27.05	Lithopone
2.1	73.83	3.58	27.30	“
2.2	74.05	-0.31	19.23	“
3	32.51	-17.07	7.97	Prussian blue
3.1	57.63	-5.94	9.82	“
3.2	18.21	-7.61	1.32	“
3.3	35.95	-9.90	4.29	“
4	10.28	-2.31	-9.20	Ultramarine blue
4.1	24.22	-3.54	-1.86	“
4.2	18.44	-3.60	2.72	“
4.3	15.15	-3.78	-0.31	“
5	41.90	39.25	19.52	Vermilion
5.1	36.10	33.63	19.59	“
5.2	48.31	36.57	31.00	“
5.3	44.39	35.64	23.17	“
6	29.77	38.50	26.43	Red lake
6.1	31.89	38.77	28.09	“
6.2	28.98	40.55	40.72	“
6.3	24.23	29.68	14.80	“
7	39.18	21.67	37.65	Iron oxide pigment
7.1	41.54	24.75	38.22	“
7.2	27.93	19.33	26.06	“
8	40.65	-20.83	24.12	Prussian blue + yellow
8.1	37.25	-18.14	26.86	“
8.2	49.31	-6.33	21.77	“
8.3	27.67	-6.46	10.78	“
9	32.83	-24.43	15.84	Unidentified green
9.1	32.51	-29.61	16.16	“

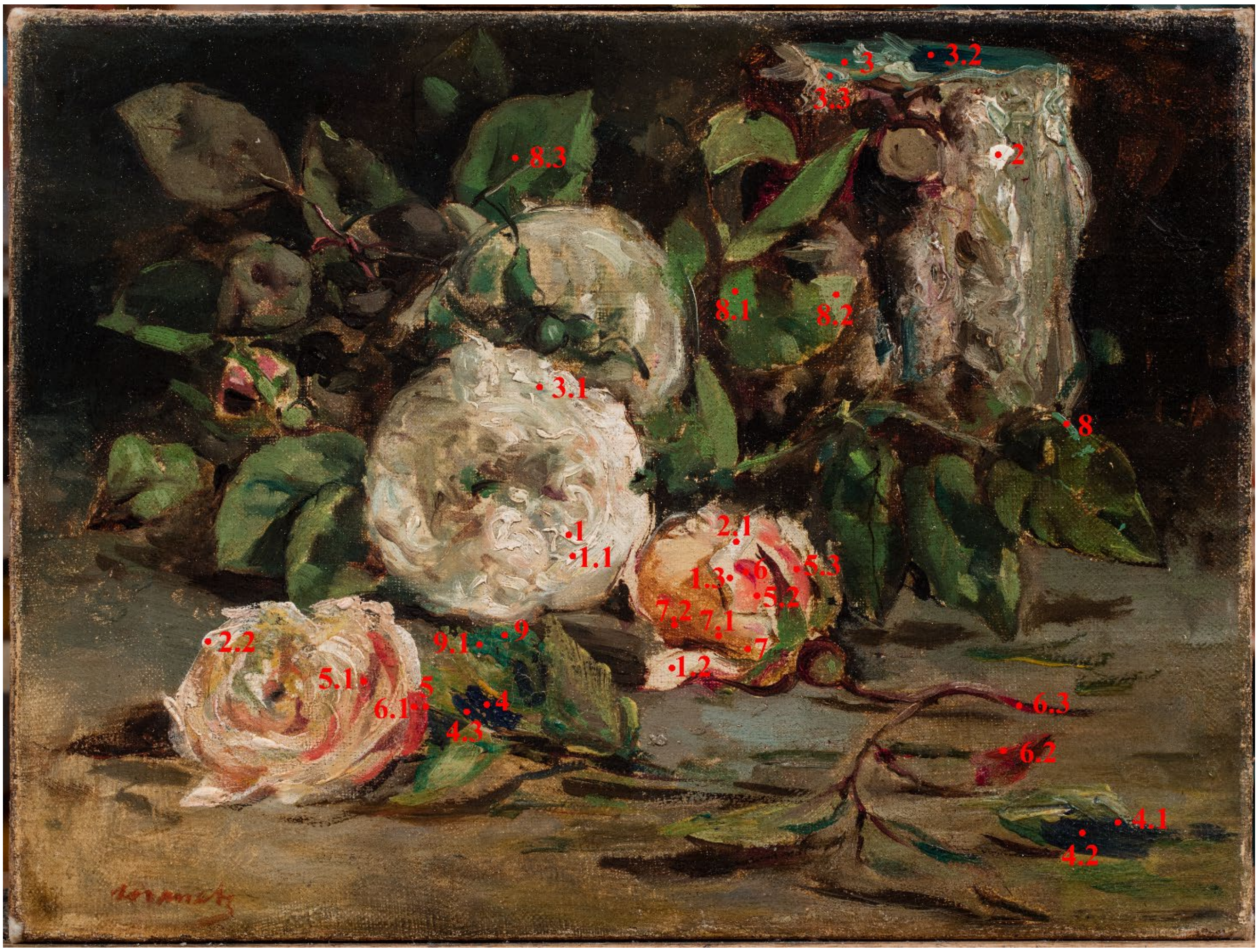

Fig. 2 – spots from which the reflectance spectra were extracted

White areas

White areas are mainly realized with lead white (basic lead carbonate $(PbCO_3)_2 \cdot Pb(OH)_2$), but there are some areas – some brushstrokes and the flower in the left corner – that are made with lithopone (mixture of barium sulfate, $BaSO_4$, and zinc sulfide, ZnS).

Colorimetric data show that both pigments have a high value of L*, since they are white pigments with a high brightness. However, lithopone has higher a* and b* values (more red and yellow components) than lead white, resulting in a warmer hue. This yellowing effect is evident even to the naked eye and might be attributable to a differentiated aging than other white zones. In addition, due to the type of lithopone used, its employment in these restricted areas might be interpreted as retouching.

Spectrally, the identification of lead white is possible because of the absorption band at 1445 nm (first OH stretching overtone) visible in the SWIR reflectance spectra. Instead, lithopone presents absorption bands at 650 nm and 730 nm, due to the presence of cobalt ions as substituents of the sulfur ion in the zinc sulfide (Fig. 3). This type of lithopone belongs to the improved version of pigment developed in the 1920s: this could confirm the hypothesis of the employment of lithopone for following retouching (Bacci, et al., 2007).

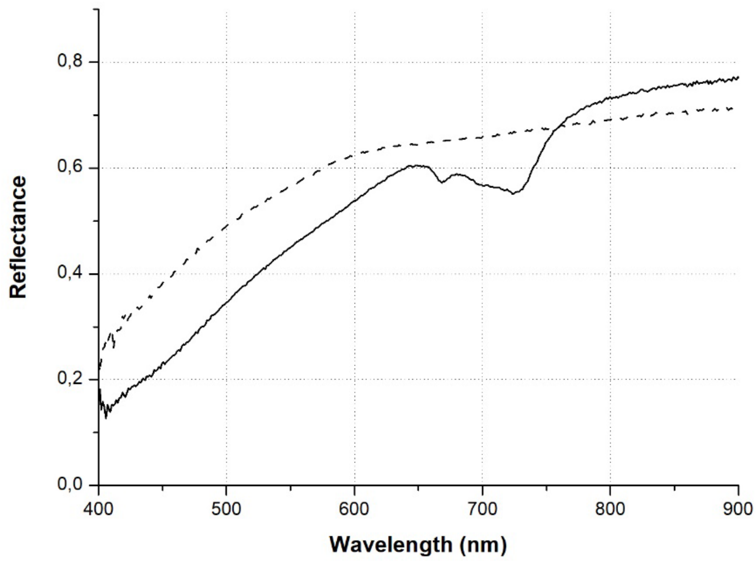

Fig. 3 – reflectance spectra of lithopone (solid line) and lead white (dash line) (AVG 5×5)

Blue areas

The blue areas are made with two different pigments: in the upper part of the painting the artist employed Prussian blue (ferric ferrocyanide, $Fe_4[Fe(CN)_6]_3$), while in the lower part some zones are obtained with the ultramarine blue (aluminum silicate and sodium sulfide, $2Na_2Al_2Si_2O_6 + NaS_2$).
In particular, the artist employed ultramarine blue to depict some shadows, therefore the resulting color is quite dark (low values of L*). On the contrary, Prussian blue was used to realize different shades of blue, from the brightest in the central flower to the darkest in the wooden log. For example, point 3.1 is a very light blue, while point 3.2 is darker, with L* values similar to ultramarine. In general, this pigment has more green and yellow components than ultramarine blue, in fact every point has a positive value of b*, that is far from the usual values of a blue pigment. For instance, point 3 shows a more greenish hue, also evident from the value of a*.
The reflectance spectrum of Prussian blue shows an absorption band at 730 nm, whereas ultramarine has an absorption band at 600 nm and both transitions are due to charge-transfer processes (Fig. 4) (Bacci, 2000) (Aceto, et al., 2014).

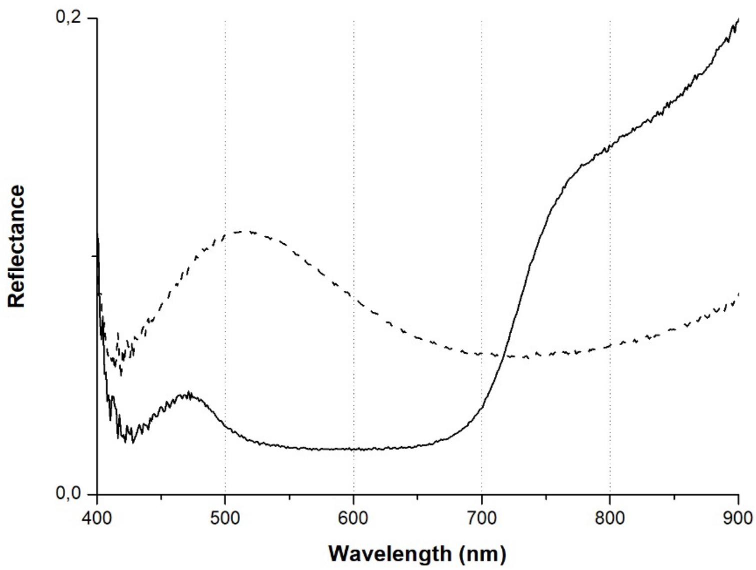

Fig. 4- reflectance spectra of ultramarine blue (solid line) and Prussian blue (dash line) (AVG 5×5)

Red areas

The two red pigments that are used in this painting are vermilion (mercury sulfide, HgS) and a red lake.

From a colorimetric point of view, the vermilion seems to be more vivid than the areas painted with the red lake (higher L* values). In general, it has a colder hue, because of the lower b* values. Nevertheless, there are still some areas that show different hues, such as point 5.2 (vermilion) that has a higher component of yellow compared to the other points. For what concerns the red lake, instead, point 6.2 has a higher value of b* than the other points, while 6.3 has a very low value of this coordinate, which means a less yellow component. This can be due to the influence of a darker pigment below the lake in this area.
In the extracted reflectance spectra (Fig. 5), vermilion shows a typical sigmoid-shaped spectrum with an inflection point at around 600 nm due to band-to-band transition. The red lake shows a similar sigmoidal trend, although with a less steep rise after the inflection point. It was not possible to define its origin (vegetal or animal) because the typical absorption bands in the 500-580 nm range are not visible (Aceto, et al., 2014) (Vitorino, et al., 2015).

Brown areas
To create brownish areas and shadows, the artist employed an iron oxide pigment (Fe_2O_3), that in fact has high values of red and yellow components (respectively a* and b*).
This pigment is identifiable from the absorption band in the reflectance spectra at 550 nm caused by charge-transfer transitions, the shoulder at 680 nm and the band at 850 nm, both due to ligand field transitions (Fig. 5) (Aceto, et al., 2014).

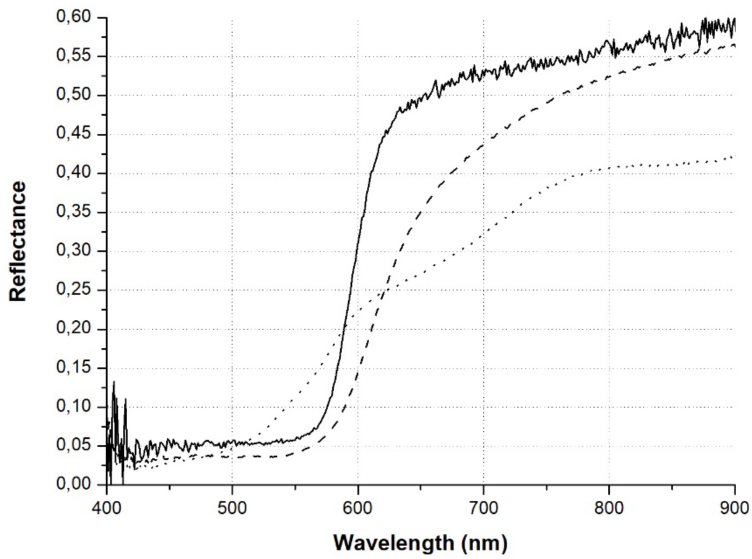

Fig. 5 – reflectance spectra of vermilion (solid line), red lake (dash line) and iron oxide pigment (dot line) (AVG 5×5)

Green areas
The greens are mostly a mixture of Prussian blue and a yellow pigment (that could be chrome yellow, lead chromate, $PbCrO_4$), but some leaves in the bottom left of the painting are obtained with another green pigment – which shows a different reflectance spectrum – that was not possible to identify, probably a copper-based pigment (Fig. 6).
The mixture has higher values of L* than the other green pigment, except for point 8.3 that refers to a darker area, with lower values of a* and b*, which translates to a minor presence of green and yellow in the color. Moreover, the unidentified green shows lower b* values which means that this pigment results colder than the mixture of Prussian blue and yellow.

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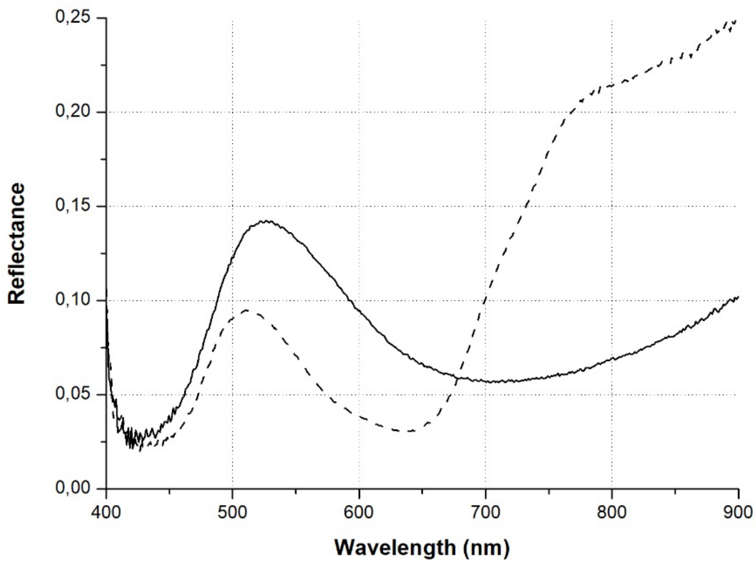

Fig. 6 – reflectance spectra of mixture of Prussian blue and yellow (solid line) and unidentified green pigment (dash line) (AVG 5×5)

Conclusion

The analyses carried out in this work confirmed how HSI is a very powerful technique in the study of artworks and their materials. The combination of colorimetric and reflectance data allowed to characterize the artist's pigments and to compare their colorimetric values. The artist employed different pigments to depict scenes with the same hue, but with some differences in their tones. In the white areas, the presence of lithopone is evident – apart from their reflectance spectra – from the more yellow hue than the lead white and can be imputed to following retouching. In the blue areas, ultramarine blue is used almost pure to realize very dark zones, while Prussian blue is employed with different shades, but in general with a greener hue. The red details are realized with vermilion and glazes with a red lake; the first one differs from the second because it is more vivid and cold. On the other hand, brown shadows and areas are obtained with an iron oxide pigment which shows higher values of red and yellow in its colorimetric coordinates. The two main green hues are depicted by using a mixture of Prussian blue and yellow and probably a Cu-based pigment: the first one is used with different shades and hues, while the second is used only in a restricted area of the painting and appears colder than the mixture.
In conclusion, HSI is a useful non-invasive technique that provide various information on the materials used to create the works of art and their artistic production techniques.

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Colors in computer heritage: investigation of "Graphite" and "Indigo" Apple iBooks from the Deutsches Museum

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Abstract
Personal computers were identical clones with a plain and colorless design until the advent of Apple iBook G3 in the late 1990s. Characterized by innovative technical properties and design, original examples of iBooks G3 are nowadays part of museum collections worldwide. The bright colors of iBooks G3 shells are part of their aesthetic, historical and material authenticity as cultural heritage objects. This work investigated the color of two iBooks G3, "Graphite" and "Indigo", gathered from the Deutsches Museum informatics collections. Both case studies served as good examples to highlight the importance of studying color in plastic-based objects and the challenge in understanding its possible alteration.

Keywords: computer heritage, plastics, museum collections, discoloration.

1. Introduction

Apple Inc. is nowadays the largest technology company worldwide. Founded in 1967 to develop personal computers, Apple Inc. has seen extraordinary success specializing in consumer electronics and computer software. However, the American multinational manufacturer of iPod, iTunes, iPhone and iPad faced a dramatic crisis in the late 1990s (Köppen, 2015). The competitors' market was expanding at the time, and the computer industry was only focused on technical features. Even though computers were getting faster and more powerful every year, they were visually static with a plain design: "a rectangular beige box alongside a bulky beige monitor, a beige keyboard and a beige computer mouse" (Lees-Maffei, 2014). To rescue the company, co-founder Steve Jobs relied on a new approach to product development that could satisfy the consumers' needs in terms of both technical performance and aesthetics. Collaborating with the designer Jonathan Ive of the Apple team, a new line of portable computer, iBook G3, was launched in 1999. Known as "Clamshell" for its shell-like shape, the iBook G3 differed from all previous laptop models of the competition (Kahney, 2013). Technically, it was a pioneer being the first computer equipped with integrated wireless networking. Its curved-round shape of the hard white computer body and bright colors of the soft plastic around the rim and bottom of the shell were significant departures from the design of the previous laptop. Conceived for students and ordinary users, the portable laptops iBook G3 were a great commercial success that rescued Apple from bankruptcy. Many technical features and design ideas first adopted in the iBooks G3 are nowadays standard in laptop computers as the multiple color options for the shell. The white and translucent colored plastics for the iBook housing were inspired by Apple's consumer desktop iMac produced at that time (Lees-Maffei, 2014). The iBooks G3 were released in several bright colors, including "Blueberry", "Tangerine", "Indigo", "Graphite" and "Key Lime". Their production was discontinued in 2000 with the debut of the next-generation iBook G3 "Snow" one year later.

Laptops iBook G3 are part of numerous private and museum collections as they represent milestones in computer science and information technology. Their impact on industrial design is also acknowledged and they are considered iconic design objects with an unmistakable layout. At present, original iBooks are on exhibition at the Yale University Art Gallery (New Haven, Connecticut, USA), Cooper Hewitt, Smithsonian Design Museum (New York City, USA), London Design Museum (London, UK), Apple Museums (Moscow, Russia; Savona, Italy), MacMuseum (Buchen, Germany), Deutsches Kunststoff Museum (Oberhausen, Germany), Die Neue Sammlung

(Munich, Germany) and Deutsches Museum (DM) (Munich, Germany). In detail, two iBook examples, respectively "Graphite" and "Indigo", are part of the DM informatics collection (Fig. 1). The iBook G3 "Graphite", permanently exhibited since 2012, features today a dramatic change of the original color of the soft plastic of the shell. The “Indigo” laptop has been in storage since 2016 (the date of its acquisition) and shows no evident signs of color alteration to the naked eye.

Fig. 1 - Two original iBooks G3 Clamshell from the informatics collection of the DM, “Graphite” (left) and “Indigo” (right).

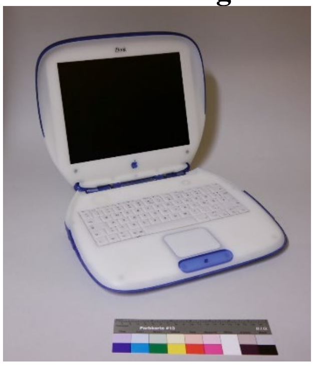
Conservation professionals have already reported the discoloration of plastic-based objects in museum collections as a decay phenomenon (Quye and Williamson, 1999; Shahoua, 2008; Lavédrine *et al*., 2012). Typically, it is related to the light-induced degradation of the formulation ingredient(s) of the plastic material, which can be perceived as yellowing, darkening, and fading (Angelin, 2021). Polymers are typically prone to yellow under light exposure. While the loss of color sensation can be ascribed to the alteration of the colorants used to adjust the color appearance of the plastic. On the other hand, additives such as antioxidants, UV-stabilizers, etc. can influence light-induced decay by prolonging the longevity of the plastic; however, they can also degrade during the plastics usage time, which can be perceived as a color change of the object (Micheluz *et al*., 2021).
Color is an integral part of the aesthetic, historical and material authenticity of the iBooks G3, which makes its investigation a priority for their proper preservation. The iBook G3 "Graphite" was recently removed from the permanent informatics exhibition due to the renovation of the DM exhibitions. This created a perfect opportunity for its study together with the “Indigo” laptop. To the best of the authors´ knowledge, no previous studies have been conducted on similar iBooks. This study intends to present preliminary results on the color and its alteration of the soft plastic around the shell. Colorimetry was applied to measure the color of both iBooks of preserved (at the naked eye) and discolored areas. Attenuated total reflectance Fourier transform infrared spectroscopy (ATR-FTIR) was used to identify the plastic type and confirm the polymer's contribution to the discolouration by identifying possible markers of its alteration.

2. Materials and Methods

2.1 Case studies

The two iBooks were gathered from the DM's informatics collections, and their specifications are reported in Table 1.

Table 1 - Resuming information of the two iBooks G3 studied.

	iBook G3 "Graphite"	**iBook G3 "Indigo"**
		
Inv.-Nr.	2012-1213T1 (Notebook)	2016-463T1 (Notebook)
Year of production	2000	2000
Place of production	Taiwan	Taiwan
Dimensions	55 x 345 x 295 mm	55 x 345 x 295 mm

2.2 Color Measurements

A Konica Minolta (Minolta Co. Ltd., Japan) CM-700d spectro-colorimeter was used to measure the color of the two iBooks. The colorimeter was equipped with an integrating sphere (Ø 40 mm), d/8° measurement geometry, and the spectral information was collected from 400 to 700 nm using a 10 nm acquisition step over a 6 mm diameter measuring area (SAV head). The light source and detector were a pulsed xenon lamp with UV cut filter and a silicon photodiode array, respectively. The instrument was calibrated with a white (100% reflective) and black (0% reference) balance, in accordance with the Konica Minolta calibration procedure. The white and black standards were provided by the manufacturer (Konica Minolta, Japan). The data reported were based on an average of three measurements including the reflected specular component (SCI mode). Color measurements were calculated for the CIEL*a*b* 1976 Color Space considering D65 standard illuminant and 10° colorimetric observer (CIE 1964). Total color variation was calculated according to CIELAB 1976 (ΔE^*_{ab}) and CIEDE2000 (ΔE_{00}) (Oleari, 2016) using SpectraMagic™ software (Konica Minolta Inc., Japan).

2.3 Attenuated total reflection Fourier-transform infrared spectroscopy (ATR-FTIR)

Infrared spectroscopy in attenuated total reflection (ATR-FTIR) was performed with an Alpha FT-IR Spectrometer (Bruker, Germany) equipped with a diamond crystal. Infrared spectra were acquired from 4000 to 400 cm^{-1} with 64 co-added scans, and 4 cm^{-1} spectral resolution. Background acquisition was carried out between every acquisition. Spectral analysis was performed using OPUS 8.1 software (Bruker, Germany). The spectra are shown as acquired, without baseline corrections or normalization.

3. Results and Discussion

Results of the color analysis highlight the dramatic color change of the iBook G3 “Graphite” (Fig. 2a,b,c). Color difference values of ΔE^*_{ab} and ΔE_{00} of 8.14 and 7.34 were obtained respectively, between the upper (point 1) and bottom sides (point 7) (Table 2). The upper part of the colored plastic of the shell is characterized by higher positive b* values, indicating yellowing. Moving along the rim (from points 1 to 7), a decrease in yellowness is detected in favor of higher negative b* values toward blue. The color change is mirrored by the broadening and blue shift of the maximum reflectance band from 500 nm to 475 nm, revealing a color change gradient alongside the shell edge.

Even though discoloration was not clearly noticed for the “Indigo” laptop by naked eye observation, ΔE^*_{ab} value indicates a visible color change ($\Delta E^*_{ab} > 2.3$ (Mahy *et al.*, 1994)) between the bottom and upper sides (Table 2, Fig. 2d,e,f). This color difference can be partially explained considering the different thickness of the soft-colored plastics, which is found to be thinner on the bottom side. The soft plastic that covers the white computer body is semitransparent. When it is less thick, the computer body becomes more evident. This hypothesis is supported by an increase in the L* values (Table 2). However, a more yellowish tone of the upper side was detected, as for the laptop "Graphite", which can be considered an incipient discoloration not perceptible by simple visual inspection.

Table 2 - CIEL*a*b* and color difference values (ΔE^*_{ab}, ΔE_{00}) collected from the upper and bottom sides of the iBooks "Graphite and "Indigo".

	Spots	L*	a*	b*	ΔE^*_{ab}	ΔE_{00}
"Graphite"	1	34,38	-4,99	1,53		
	7	39,48	-3,39	-4,61	8,14	7,34
"Indigo"	1	36,02	-4,54	-16,6		
	7	38,66	-2,99	-21,18	5,51	3,56

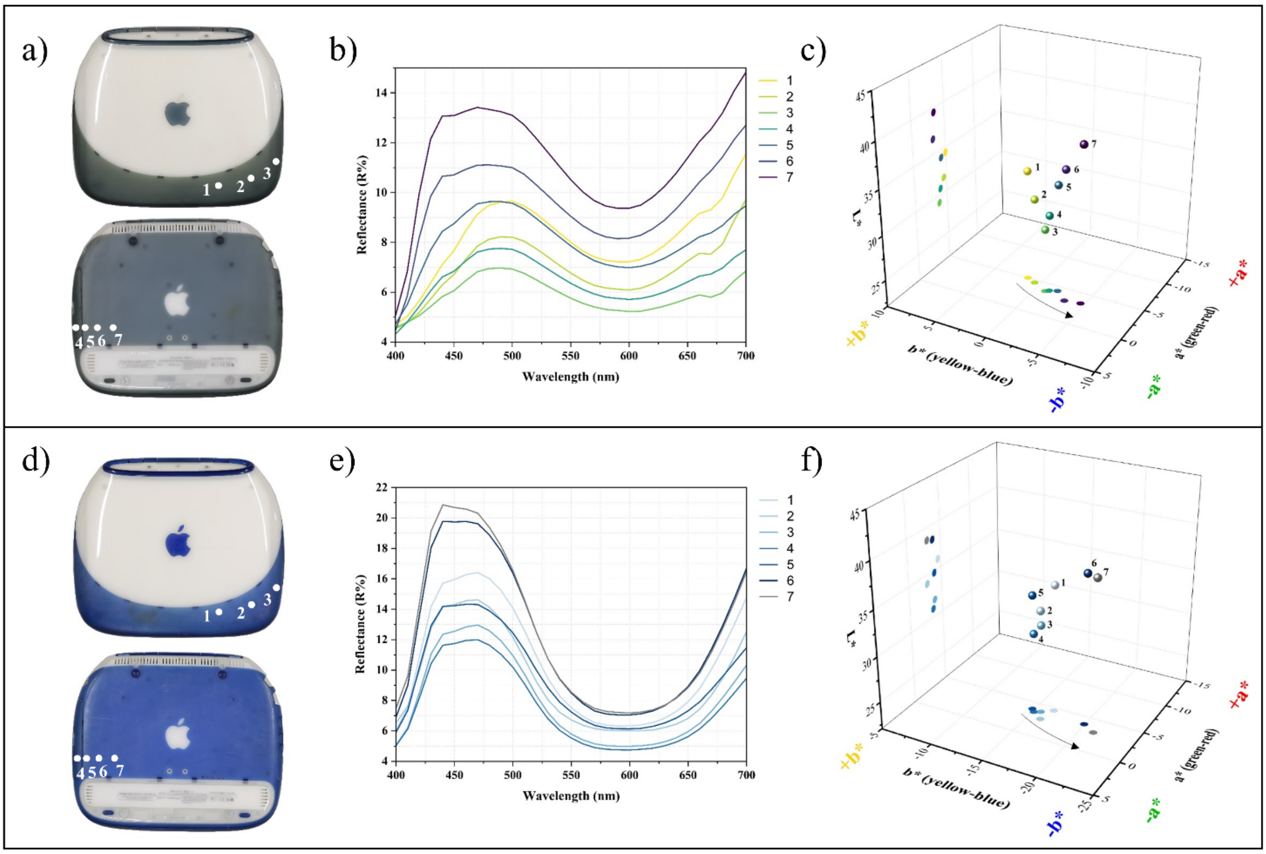


Fig. 2 - "Graphite" (a) and "Indigo" (d) iBooks G3, reflectance spectra (b,e) and L*, a*, b* values in 3-dimensional CIELab76 Color Space (c,f). Projections of the points along L* vertical axis and a* and b* perpendicular horizontal axes are also reported.

Figure 3 shows the ATR-FTIR spectra collected from the upper and bottom sides of the "Graphite" and "Indigo" iBooks. The polymer is identified as polyurethane (PUR) elastomer for both laptops, presenting a good match with n. 65 of the SamCo collection for plastic identification (Lavédrine *et al.*, 2012). Furthermore, a specific absorption band for ethers-based PUR elastomer around 1078 cm^{-1} was identified (de Groot *et al.*, 2013). PUR ether elastomers are rubber-like materials known by conservation professionals for their sensitivity to light and photo-oxidation (Micheluz *et al.*, 2022), and yellowing is typically a symptom of the light-induced molecular modification of the PUR polymer chains (Rabek, 1995). ATR-FTIR spectra of the upper sides display similar changes with the formation of a new band centered at 1650 cm^{-1} and modification in the relative intensity of the infrared bands between 1160 and 1120 cm^{-1}. If one considers the bottom sides as not degraded, those molecular modifications might be associated with photo-oxidation functions (Bousquet and

Fouassier, 1983). However, complete identification of the chemical composition of the PUR ether elastomer deserves further investigation to explain such molecular modifications as the formation of the decay photoproducts is influenced by the type of PUR.

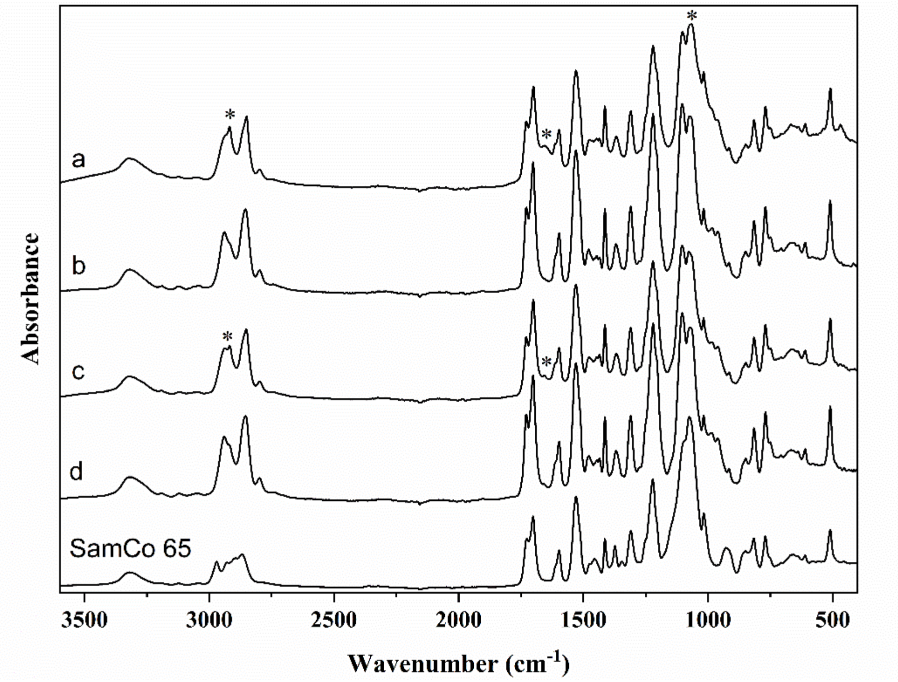


Fig. 3 - ATR-FTIR spectra top (a,c) and bottom (b,d) sides of the iBooks G3 Graphite and Indigo respectively. ATR-FTIR spectrum of SamCo 65 Uretane Elastomer Thermoplastic (TPU) is reported for comparison. Bands referred to molecular change are indicated (*).

4. Conclusions

The color analysis confirmed the dramatic color change of the iBook "Graphite". The color gradient observed alongside the rim can support the hypothesis of light-induced damage of the areas more exposed to direct light (upper side). The polymer – PUR ether elastomer – might be responsible for the yellowing of the upper side. Future work will include the characterization of the chemical composition of the PUR polymer to understand the yellowing entity. Nonetheless, the polymer type on its own is not an exhaustive indicator of which molecular alterations are due to light exposure, and the formulation triad "polymer-colorants-additives" should be taken into account (Angelin, 2021). Therefore, identification of the colorants and additives remains a topic for future research, and it will support a better insight into the iBooks discoloration. Colorimetric analysis was able to detect the incipient yellowing of the iBook "Indigo" not identified by simple visual observation. This study highlights the importance of investigating and monitoring color as a reliable tool for assessing degradation in museum collections.

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Between West and East: a non-invasive study of colourants on Syriac manuscripts

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Abstract

Syriac manuscripts represent an important treasure as they document the spread of early Christian iconography throughout the Eastern Mediterranean. While they are well-known from the historical, artistic and religious literary points of view, the knowledge of the pictorial materials with which they were produced is only in its infancy. Few of them have been subjected to diagnostic analysis, the most important being the 6th century *Rabbula Gospels* kept in Florence at Biblioteca Medicea Laurenziana (cod. Plut. I, 56). The present contribution reports on the results obtained from the identification of colourants in two important groups of Syriac manuscripts, the first one kept in Paris at Bibliothèque nationale de France (BnF) and the second one kept in Rome at Biblioteca Apostolica Vaticana (BAV). As a whole set, the manuscripts date from the 6th to the 14th century.
The diagnostic study has been carried out in totally non-invasive way. The techniques used were UV-visible diffuse reflectance spectrophotometry with optic fibres (FORS), X-ray Fluorescence Spectrometry (XRF), Fibre Optic Molecular Fluorimetry (FOMF) and Optical Microscopy (OM). The FORS technique was systematically applied to have a preliminary identification of the colourants and in most of the cases allowed having a reliable identification. FOMF analysis was used to confirm some uncertain results. XRF spectrometry was used to support FORS identification and to have information on the metal pigments. Optical microscopy, finally, was used to have a view under the micro scale, useful to aid the identification obtained by the spectroscopic techniques.
The results obtained show that precious colourants, such as lapis lazuli, cinnabar and insect dyes, were widely used, apart from the oldest manuscript (ms. Syriaque 33 - BnF). One remarkable group of manuscripts is the one formed by the 12th-13th century manuscripts Syriaque 30, 40, 41, 54, 355, 356 (BnF) and Vat. Sir. 559 (BAV): these manuscripts contain miniatures decorated with lapis lazuli, pararealgar (an unusual yellow pigment, possibly produced by alteration of realgar), iron gall ink (a pigment of Western tradition, very unusual in Asian countries) and an insect dye, most probably derived from the Indian scale insect *Kerria lacca*. This set of colourants appears to be a synthesis between Asian and European cultures and it is quite different from the palette used in the oldest manuscripts.
Despite being only a small fraction of the existing Syriac manuscripts, the results here presented can be considered a preliminary view of the colourants used by the early and late medieval artists of this cultural area. It is advisable that further analyses will be carried out to have a more complete view of the Syriac miniature painting art.
This contribution is in loving memory of Prof. Guido Frison, colleague and friend as well as a source of inspiration for this and a thousand other projects.

Keywords: Syriac, manuscripts, non-invasive, colourants, FORS, XRF.

Introduction

Syriac manuscripts represent an important treasure as they document the spread of early Christian iconography throughout the Eastern Mediterranean. While they are well-known from the historical, artistic and religious literary points of view, the knowledge of the pictorial materials with which

they were produced is only in its infancy. Very few of them have been subjected to diagnostic analysis, the most important being the 6th century *Rabbula Gospels* (cod. Plut. I, 56) kept in Florence at Biblioteca Medicea Laurenziana which was analysed by Lanterna *et al.* (Lanterna, Picollo and Radicati, 2008). Another manuscript, dated to the first half of 13th century, is ms. Add. 7170 kept at British Library in London, analysed by Clark and Gibbs by means of Raman spectroscopy (Clark and Gibbs, 1997).
The present contribution reports on the results obtained from the identification of colourants in two important groups of Syriac manuscripts, the first one kept in Paris at Bibliothèque nationale de France (BnF) and the second one kept in Rome at Biblioteca Apostolica Vaticana (BAV). As a whole set, the manuscripts date from the 6th to the 14th century.
The diagnostic study has been carried out in totally non-invasive way. The techniques used were UV-visible diffuse reflectance spectrophotometry with optic fibres (FORS), X-ray Fluorescence Spectrometry (XRF), Fibre Optic Molecular Fluorimetry (FOMF) and Optical Microscopy (OM). The FORS technique was systematically applied to have a preliminary identification of the colourants and in most of the cases allowed having a reliable identification. FOMF analysis was used to confirm some uncertain results. XRF spectrometry was used to support FORS identification and to have information on the metal pigments. Optical microscopy, finally, was used to have a view under the micro scale, useful to aid the identification obtained by the spectroscopic techniques.

Materials and methods

UV-visible diffuse reflectance spectrophotometry with optic fibres (FORS): FORS analysis was performed with an Avantes (Apeldoorn, The Netherlands) AvaSpec-ULS2048XL-USB2 model spectrophotometer and an AvaLight-HAL-S-IND tungsten halogen light source with a wavelength range of 360–2500 nm; the detector and light source were connected with fibre optic cables to an Avantes FCR-7UV200-2-1,5x100 reflection probe. In this configuration, light is sent and retrieved with a unique fibre bundle positioned at 45° from the surface normal, in order not to include specular reflectance. The spectral range of the detector was 200–1160 nm; depending on the features of the monochromator (slit width 50 µm, grating of UA type with 300 lines/mm) and of the detector (2048 pixels), the best spectra resolution was 2.4 nm calculated as FWHM. The diffuse reflectance spectra of the samples were referenced against the WS-2 reference tile provided by Avantes and guaranteed to be reflective at 98% or more in the spectral range investigated. The investigated area on the sample had a 1 mm diameter. In all measurements the distance between the probe and the sample was kept constant at 2 mm, corresponding to the focal length; the probe was inserted into a small aluminium block. To visualise the investigated area on the sample, the block contained a USB endoscope. The instrumental parameters were as follows: 10 ms integration time, 100 scans for a total acquisition time of 1.0 s for each spectrum. The system was managed with AvaSoft v. 8 dedicated software running under Windows 7.

X-ray Fluorescence Spectrometry (XRF): XRF measurements were performed with an EDXRF Thermo (Waltham, MA, USA) NITON spectrometer XL3T-900 GOLDD model, equipped with a Ag tube (max. 50 kV, 100 µA, 2 W), a large area SDD detector and an energy resolution of about 136 eV at 5.9 keV. The analysed spot had an average diameter of 3 or 8 mm and was focused by a CCD camera, with a working distance of 2 mm. The total time of analysis was 240 s. The in-strument was held in position with a moving stage allowing micrometric shifts, in order to reach the desired probe-to-sample distance; the stage was laid on a tripod. The obtained spectra were processed with the commercial software bAxil, derived by the ac-ademic software QXAS from IAEA.

Fibre Optic Molecular Fluorimetry (FOMF): an Ocean Optics (Dunedin, FL, USA) Jaz model spectrophotometer was employed to measure the molecular fluorescence spectra. The instrument was equipped with a 365 nm Jaz-LED internal light source and an Avantes FCR-7UV200-2-

1,5x100 reflection probe used to drive excitation light on the sample and to recover emitted light. The spectrophotometer was working in the range 191–886 nm; according to the features of the monochromator (200 µm slit width) and the detector (2048 elements), the spectral resolution available was 7.6 nm calculated as FWHM. The investigated area on the sample was 1 mm in diameter. In all measurements the distance between the probe and the sample was kept constant at 1.2 mm, corresponding to the focal length; the probe was inserted into a small aluminium block in order to exclude contributions from ex-ternal light. To visualise the investigated area on the sample, the block contained a USB endoscope. Instrumental parameters were as follows: 3 s integration time, 3 scans for a total acquisition time of 9 s for every spectrum. The system was managed with Spec-traSuite software running under Windows 7.

Optical Microscopy (OM): a Dino-Lite (Naarden, The Netherlands) AM413TL-FVW model optical microscope was employed to record digital images from the parchment. The microscope allows magnification in the range 20x–90x.

Results and discussion

Most of the colourants were identified by means of FORS analysis and confirmed by means of FOMF and XRF. While for most of them the identification can be considered as reliable, according to the minima and/or the inflection points present in the spectrum that fit well those reported by the scientific literature (Aceto *et al.*, 2014), in a few cases a certain grade of uncertainty must be declared. In particular, two cases must be cited:

- the identification of lac dye relies on the absorption features in the FORS spectrum of purple, pink and violet paints, typical of anthraquinone dyes. As it is well known, it is relatively easy to distinguish between vegetal (madder) and animal (kermes, Armenian cochineal, Mexican cochineal, Polish cochineal and lac dye) anthraquinone dyes according to the spectral features of the FORS responses: the typical absorption bands occur at 510 and 540 nm for madder and at 520-535 and 560-575 nm for the animal dyes. Among the animal dyes, it was recently noted (Aceto *et al.*, 2019) that the absorption bands of lac dye occur at longer wavelengths, typically 530-535 and 565-575 nm. This hypothesis has been reinforced by means of a few micro-invasive measurements by means of HPLC-MS analysis, that confirmed the exclusive presence of laccaic acids in samples where the presence of lac dye was suggested by FORS.
- the identification of the yellow pigment pararealgar is suggested by the inflection point in the FORS spectrum, occurring between 500 and 515 nm, by the presence of As and S in the XRF spectrum and by the strong emission peak in the FOMF spectrum, occurring between 545 and 560 nm; these features suggest that the pigment is pararealgar and not orpiment, nor any other yellow pigment or dye. The identification, however, could not be unequivocally confirmed by means of Raman analysis.

The list of the manuscripts analysed is reported in Tab. 1.

Source	Signature	Period	Provenance
Bibliothèque nationale de France	Syriaque 33	6th	Turkey
Bibliothèque nationale de France	Syriaque 341	6th-7th	Iraq
Bibliothèque nationale de France	Syriaque 27	8th	Syria
Biblioteca Apostolica Vaticana	Vat. Sir. 13	8th	
Biblioteca Apostolica Vaticana	Vat. Sir. 529	9th-11th	
Biblioteca Apostolica Vaticana	Barb. Or. 118	10th-11th	
Biblioteca Apostolica Vaticana	Vat. Sir. 94	11th	Turkey
Biblioteca Apostolica Vaticana	Vat. Sir. 118	12th	

Bibliothèque nationale de France	Syriaque 30	12th	Turkey
Bibliothèque nationale de France	Syriaque 40	12th	Syria
Bibliothèque nationale de France	Syriaque 41	12th	Turkey
Bibliothèque nationale de France	Syriaque 54	12th	Syria
Bibliothèque nationale de France	Syriaque 355	12th	Turkey
Bibliothèque nationale de France	Syriaque 356	12th-13th	Turkey
Bibliothèque nationale de France	Syriaque 112	13th	Turkey
Biblioteca Apostolica Vaticana	Vat. Sir. 559	13th	Mosul (Iraq)
Biblioteca Apostolica Vaticana	Vat. Sir. 622	13th	Iraq

Tab. 1 – List of manuscripts analysed in this study

In particular, two groups of manuscripts were taken into consideration:

- the oldest ones, BnF Syriaque 33 and 341, dated to 6th-7th centuries;
- an homogeneous group of 12-13th centuries manuscripts (BAV Vat. Sir. 559 and BfN Syriaque 30, 40, 41, 54, 355 and 356) produced between Syria, Turkey and Iraq.

The oldest manuscripts. Ms. BnF Syriaque 33 or *Tétraévangile syriaque*, produced in Syria or Turkey, is dated to 6th century; ms. BnF Syriaque 341 or *Bible syriaque*, most probably produced in Iraq, is dated to 6th-7th centuries. Though very close in time, they have a remarkably different palette. One common feature is the use of irongall ink for the text, which is unusual for manuscripts written in Asian areas where the use of carbon inks was much more common. The introduction of irongall ink is uncertain both from the historical and the geographical point of view, but the first analytical evidence of the use is reported to be in the Western part of the Mediterranean Basin, with reference to the *Vercelli Gospels* (Aceto *et al.*, 2008) and the *Codex Sinaiticus* (Moorhead *et al.*, 2015), respectively produced in Italy and in Egypt.

Ms Syriaque 33 was decorated with indigo, indigo/orpiment mixture (for the green hues), cinnabar, red lead, madder and orpiment. As cited above, the text was written with an irongall ink. The palette seems to be close to those of the late antique manuscripts *Ilias picta*, *Vergilius Romanus*, *Vergilius Vaticanus* (Aceto *et al.*, unpublished results) which recall the Roman tradition.

The palette of ms. BnF Syriaque 341 is richer and more variegate. In fact, it contains ultramarine blue, azurite and indigo, gold, verdigris and indigo/orpiment mixture, cinnabar, red lead, madder and yellow ochre. The text was written with an irongall ink. Of particular interest is the use of ultramarine blue, the pigment obtained from the semiprecious stone lapis lazuli, here used in one of the earliest occurrences ever recorded, surely favoured by the proximity of Iraq to the lapis lazuli mines of Badakshan (present-day northeastern Afghanistan). The use of gold is remarkable as well and suggests that this set of colourants is closer to those of the early medieval manuscripts and in particular of the three 6th century purple codices *Vienna Genesis*, *Rossano Gospels* and *Codex Sinopensis*.

The group of 12th-13th centuries manuscripts. These manuscripts, produced in an area between Syria, Turkey and Iraq, show a very homogeneous and characteristic palette. It is composed by ultramarine blue and indigo; verdigris and a mixture of indigo and a yellow colourant; gold; cinnabar; a scale insect dye, most probably lac dye; pararealgar. As for the older manuscripts, the text was written with an irongall ink. The most remarkable points of this palette are the following:

- the systematic use of ultramarine blue: this is a feature typical of all the Near Eastern and Middle Eastern Asian painting schools (Persian, Ottoman, Turkish, etc.). Again, this must be favoured by the proximity of the Badakshan mines, but it is nevertheless a clear sign of richness.

- the use of lac dye, a dye obtained from the *Kerria lacca* scale insect, typical of the Indian subcontinent. This seems to suggest a link between the Syriac-speaking area and India. Interestingly, the Syriac church has a long history in India that is traditionally dated to the 1st century AD, when St. Thomas the Apostle is believed to have landed in Kerala (Perczel, 2019).
- the uncommon use of pararealgar, a yellow arsenic sulphide - As_4S_4 – naturally occurring as light-induced alteration phase of the orange mineral realgar – same formula – or artificially produced by photodegradation of realgar itself. It is interesting to note that in nearly all instances where pararealgar was found, the yellow colour was coherent from the iconographic point of view, so to suggest that the Syriac artisans were able to exploit the photodegradation of realgar to obtain a new yellow pigment. Pararealgar was known to ancient Egyptians (Burgio and Clark, 2000; Daniels and Leach, 2004) but it has rarely been reported on medieval manuscripts, and only in paintings from Middle Eastern Asia. Clark and Gibbs identified it on the manuscript Add. 7170 kept at British Library in London (Clark and Gibbs, 1997), not by chance produced near Mosul (Iraq) and showing a strong relationship with ms. Vat. Sir. 559 of Biblioteca Apostolica Vaticana. Knipe et al. identified pararealgar in manuscripts from Iraq and Iran dated respectively to 13th and 14th centuries (Knipe *et al.*, 2018). Later identification from nearby geographic areas was reported by Muralha *et al.* in a 16th century Persian manuscript (Muralha, Burgio and Clark, 2012), by Burgio *et al.* in two 16th century Ottoman manuscript (Burgio *et al.*, 2008) and by Jurado-López *et al.* in a 16th century Turkish manuscript (Jurado-López *et al.*, 2004). The exclusive occurrence of pararealgar on these Syriac manuscripts and in all other evidence cited can be explained by the wide availability of realgar mines in the area between Turkey and Iran.
- the use of irongall inks for the text: while nearly all of the Islamic documents were written in carbon inks, most of the medieval Western documents were written with irongall inks, so this seems to suggest a strong "Western" influence on the scribes who wrote these Syriac manuscripts.

In the end, it is interesting to compare the palette of the group of 12-13th centuries Syriac manuscripts with typical late medieval "Western" and "Oriental" palettes (Tab. 2).

Colour	12th-13th century Syriac	Oriental	Western
black	irongall ink	carbon	irongall ink
blue	ultramarine blue	ultramarine blue	ultramarine blue azurite indigo
gold	gold	gold	gold mosaic gold
green	verdigris indigo/yellow colourant	verdigris indigo/yellow colourant	verdigris indigo/yellow colourant
orange	cinnabar	red lead	red lead
pink/purple/violet	scale insect dye (lac dye)	scale insect dye	scale insect dye
red	cinnabar	cinnabar red lead	cinnabar red lead
yellow	pararealgar	orpiment	orpiment yellow ochre

Tab. 2 – Comparison of palettes

In the end, the palette of the Syriac manuscripts seems to be influenced both by the Western (irongall ink) and the Oriental (lapis lazuli, lac dye) traditions.

Conclusions

Despite being only a small fraction of the existing Syriac manuscripts, the results here presented can be considered a preliminary view of the colourants used by the early and late medieval artists of this cultural area. It is advisable that further analyses will be carried out to have a more complete view of the Syriac miniature painting art.

This contribution is in loving memory of Prof. Guido Frison, colleague and friend as well as a source of inspiration for this and a thousand other projects.

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Color = Shape = Space: Sol LeWitt's Wall Drawing #736 "Rectangles of color"

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Abstract

The wall drawings are among the most famous works of the American artist Sol Lewiitt (1928-2007), considered one of the founding fathers of Conceptual Art. Over the course of about 38 years he made about 3500 of them, considering the different versions, in 1200 different places, 350 of which in Italy where he chose to reside almost permanently after buying a house in Spoleto in 1982; the first are executed directly on the wall by the artist, but above all what makes these creations peculiar is the fact that very soon he chooses to deal exclusively with the project, delegating the realization of the work to specialized operators, each of whom interprets the instructions in a personal way. It is therefore a question of variable and multiple works, based on a principle of collaboration. To define this relationship between ideation and execution Sol Lewitt often used the metaphor of the musical score: "I think of them [the wall drawings] as a musical score that has to be remade by someone or by some people. I like the idea that the same work can exist in two or more places at the same time ". During 2021 the Wall Paintings and Stucco Department and the Contemporary Art Service of the Opificio delle Pietre Dure intervened for maintenance on the wall drawing # 736 Rectangles of colour of the Luigi Pecci Center for Contemporary Arts in Prato, created in 1993: it was the opportunity for a comparison with this category of works by the American artist that have almost become "school" when we intend to speak of the paradigm change that certain part of contemporary art requires from a conservative point of view, because it escapes a concept of authenticity intended as an autograph. It is a long geometric frieze (in this sense a unicum in the conspicuous corpus of wall drawings by the artist) of which the rectangle represents the basic modular element, repeated in the variations of size and color, designed to dialogue with the space a circular plan and also with the furnishings that it should have housed, obtained through the use, very unusual for a wall painting, of Drawing Ink Z® by Pelikan, usually used in architectural drawing and in four-color heliographic printing, for years out of production, characterized by a high resistance to light and capable of giving the painted surface an extraordinary almost translucent brilliance, similar to that of a fresco, applied by successive glazes.

To continue with the musical metaphor, Lewitt orchestrates an extraordinary symphony of colors with his wall drawings, in which each color, while maintaining its own individuality, contributes to the overall result.

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7. Color and Environment

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Colouring in Architecture: problems involving nocturnal representation

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Abstract

The visibility of an architecture changes enormously throughout the day depending on whether the light source is diurnal, nocturnal, natural, artificial or mixed.
Since perception of the same building changes, we always need to experiment with suitable representation systems in order to convey these changes in colour.
Several methods can be used to understand these effects; they include photography and all kinds of drawings, be they analogical or digital.
The big difference in architectural representations is the contrast between light and shadow, the absence of colour, the use of black and white, and the descriptions of the different colour intensities and tones.
Since daytime representations have been studied the most, even by me, my contribution will focus on the nocturnal representation of architecture, a topic that still needs to be examined in-depth by anyone involved with drawing.
I have chosen several subjects which I will draw at a certain time of night: the castle on the island of Patmos (Greece), the castle in the city of Blanca (Mursia region, Spain), and the Cathedral in Orbetello (Tuscany): my goal is to try and represent on paper the many phenomena of light and colour which are always a priority compared to the form and intangible narrative of the architecture.
Instead to express colour differences during the night, I have chosen just one building that I can access more easily: a farmhouse in the hamlet of Titignano (Orvieto, Umbria).

Keywords: nocturnal representation, colouring architecture, perception, fruition.

Introduction

When analysing built heritage, it is important to identify and represent the chromatic values that materials assume during the day and at night in order to convey the tangible and intangible essence of architectural reality.
In fact, the chromatic variations of an architecture during the day depend on many factors; they include the seasons, (spring, summer, autumn and winter), the time of day or night, and the weather (sunny, cloudy, dull, windy, rainy, foggy, etc.). These factors modify the perception of the architecture and the intensity of its shadows, thus altering the way we see the object and producing a cultural recognisability that always varies.
Although the colour of an architecture is an objective colour, it is also, inevitably, subjective and emotional; when identified by expert and sensitive researchers it paves the way for critical representations/interpretations that can be used to monitor the lifecycle of the object.
I believe that architecture is influenced by the type of light source, especially at night.
When materials are lit by natural light, i.e., only by the moon, the stars and/or the bright night sky, the reflections on the material façades of buildings are primarily opaque, but when artificial light is involved the results are generally more brilliant.
That said, we can describe an architecture as luminous when light comes from inside the building, while an illuminated building is an architecture that is lit by the light provided by its urban context.
The internal lighting in public luminous architectures (i.e., museums, churches, castles and buildings) has usually been carefully designed, while private buildings tend to have different kinds of light sources with very diverse luminous intensities, thus creating heterogeneous compositions.
Instead illuminated architecture is often dependent on the rationale behind the design of the visibility and safety of the road or square where the artefact is located.

Since various factors make the perception of nocturnal urban reality extremely diverse and changeable, we have to constantly experiment with different dynamic representation methods since the latter can highlight the cultural identity values that our architectural heritage always conveys, even at night.
The issues regarding perception of the nocturnal variability of architecture were also inspired by the artistic and pictorial studies by the French artist Claude Monet when he drew the Cathedral in Rouen (Normandy) between 1892 and 1893 (Fig. 1).

Fig. 1 – Claude Monet's series of graphic representations of the Cathedral in Rouen in Normandy (1892-1893)

The double life of architecture

Architecture therefore has a double life; a mercurial diurnal and nocturnal dimension that perceptively alters its features.
Performing numerous experiments with the students of the Faculty of Architecture of Rome, the graduates enrolled in the PhD course in History, Drawing and Restoration of Architecture, the postgraduate students of the School of Specialisation in Architectural Heritage and the Landscape, and after organising numerous Higher Education workshops on this subject, I have for many years continued to research the different ways in which the nocturnal colours of architecture can be portrayed.
The drawings presented here unavoidably merge my knowledge of techniques, materials, geometric values and the theory of shadows with my artistic sensitivity, thus producing accurate, harmonious graphic narrations that represent and enhance our nocturnal heritage, be it real or ephemeral.
Critical nocturnal graphic representations are crucial not only because they make it possible to present new and different chromatic values of buildings, compared to the ones perceived during the day, but above all because they can be used as basic study material when embarking on design and enhancement processes or projects with broader objectives involving the buildings in question.
These drawings can also be used to highlight the possible alterations caused by fierce illumination that can distort visibility (especially as regards public buildings) due to the strong, phosphorescent and/or very brilliant colours used to light the buildings, thus preventing perception of their architectural value. In fact, the urban lighting in some cities around the world is used in an improper and insensitive manner, making those cities look like fun fairs.

The night as a performance. Graphic experimentation.

The effects produced by luminous and illuminated architecture are always spectacular and unique. We could say that architecture has a nocturnal personality, highlighted by perception. Night-time architectures can be considered big, multifaceted nocturnal stage sets, but also experiences, symbols and events that are important in order to make the late-night landscape recognisable.
Reference points in space are different during the day and at night; they are not always equivalent and this depends on the diverse characteristics of the light sources.

The artefacts I have chosen all differ in shape, type, period of production, and function; my objective was to test a common representation method by personally producing a watercolour drawing of a nocturnal scene because it captures and records shimmers, transparencies, effects, and vibrations in a direct, intuitive, simple, and immediate manner. The castle on the island of Patmos (Greece), the castle in the city of Blanca (Mursia region, Spain), and the Cathedral in Orbetello (Tuscany) were all drawn at the same time at night (11pm). My goal was to try and transcribe on paper the many effects of light and colour that always take priority over the form and narration of an architecture. The three buildings are located in different countries and have different surroundings: an island, a small Spanish town overlooking a river, and the lagoon landscape of a town in Tuscany. However, although the settings are very diverse due to the conformation of the territory and the atmosphere of the sites, the drawings try and capture the essence, nature, and character of buildings vis-à-vis their specific location.
The use of saturated colours (blue, black, yellow, ochre) made it possible to represent the luminous chromatic contrasts that were the most important when interpreting the buildings, including in relation to the white piece of paper. The dark sky at night, albeit with diverse chromatic variations, sharply outlined their shape, highlighting the different spatial conformations and simplifying their volumes. (Figs. 2, 3, 4).

Fig. 2 – The castle on the Island of Patmos, Greece. Nocturnal effects, watercolour

Fig. 3 – The castle in the city of Blanca, Mursia, Spain. Nocturnal effects, watercolour

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Fig. 4 – The Cathedral in Orbetello, Tuscany. Nocturnal effects, watercolour

Instead to illustrate colour changes during the night I am presenting a series of nocturnal graphic variations of a castle in Umbria; these watercolours, painted in August 2022, all portray a building from the same viewpoint. The changes in the chromatic values of these perspectives depend on the kind of light (natural, artificial, or sometimes even mixed) reflected on the material façade. I chose not to paint a traditional view (i.e., an elevation), but used a corner perspective so as to place it in its natural setting (Fig. 5).

Fig. 5 – The Farmhouse in Titignano, Orvieto, Umbria. Watercolour.

As in music, where it is possible to compose an infinite number of variations on a theme, numerous grammatical diversifications can be invented when writing. Likewise, nocturnal architectural representations can be graphically expressed by an endless number of variables: tones, colours, luminosity and atmospheric effects (Fig. 6).

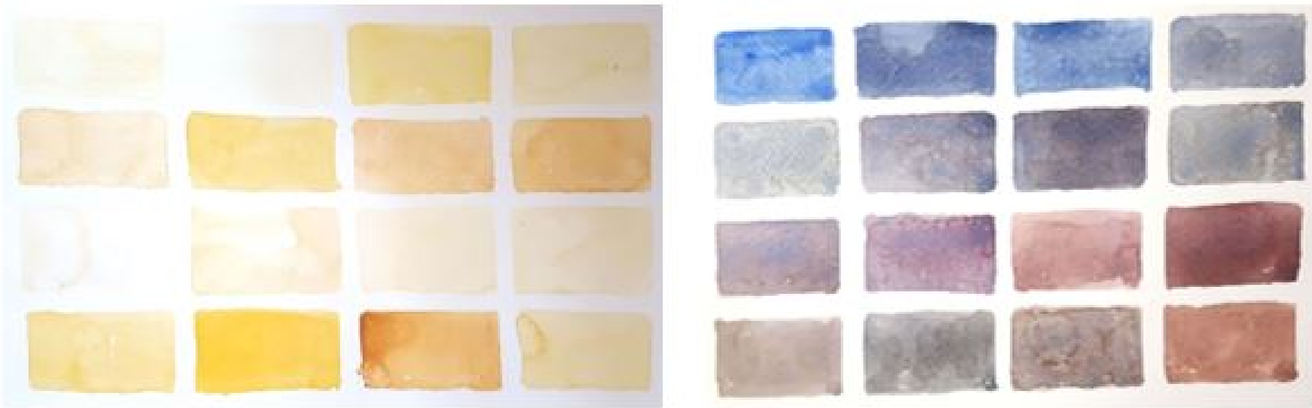

Fig. 6 – Colours for nocturnal representation: natural and artificial lights

This allowed me to study and examine what the architecture looked like depending on the time of day, the weather, the season, and different atmospheric conditions. It demonstrated how, thanks to light and colour, a building - whatever its type and shape – can generate visual stimuli and spatial emotions that are always new and interesting. (Figs. 7,8)

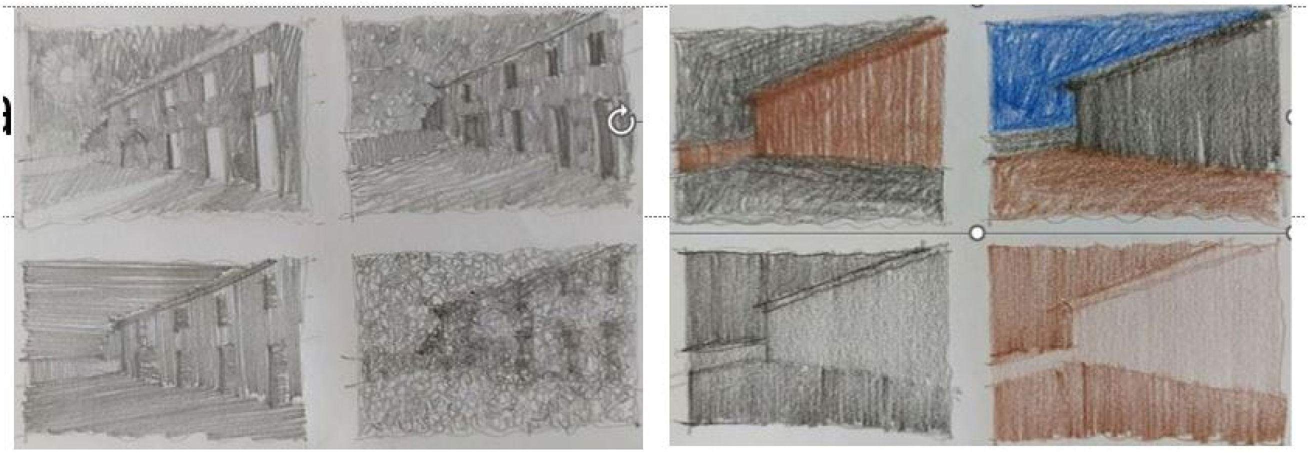

Fig. 7 – The Farmhouse in Titignano, Orvieto, Umbria. Studies on the effects of light

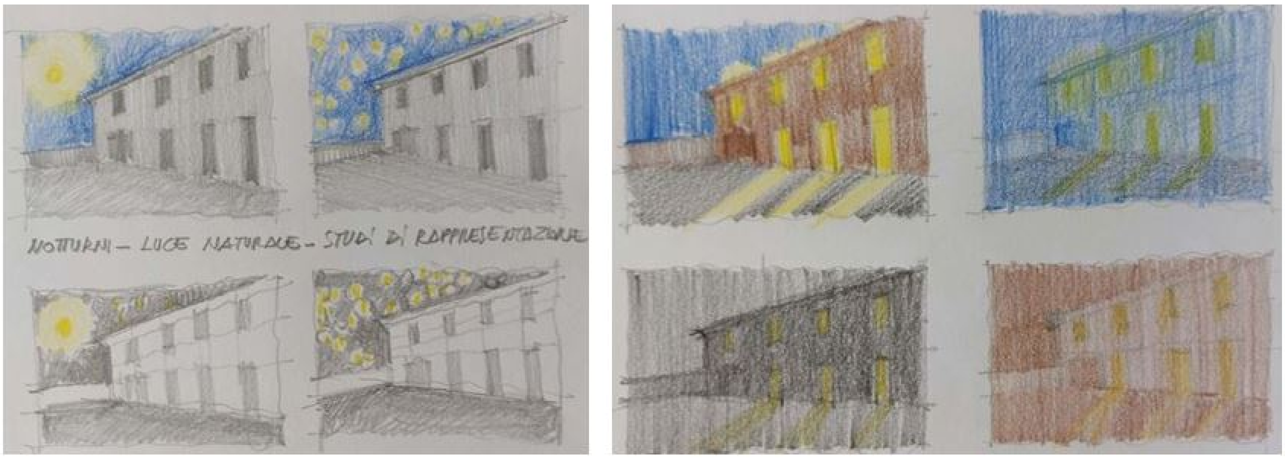

Fig. 8 – The Farmhouse in Titignano, Orvieto, Umbria. Studies on the effects of light

This sequence of nocturnal representations was executed at different times, starting with the early evening and ending at midnight; my intention was to highlight the different chromatic expressions that can be perceived as the night passes and also capture what the architecture conveys when there are changes in the intensity of the light (Figs. 9,10,11,12).

Fig. 9 – The Farmhouse in Titignano, Orvieto, Umbria. Light effects after sunset, watercolour (6 August 2022, 8.00pm and 9.00pm)

Fig. 10 – The Farmhouse in Titignano, Orvieto, Umbria. Light effects, watercolour (7 August 2022, 10.00pm and 11.00pm)

Fig. 11 – The Farmhouse in Titignano, Orvieto, Umbria. Light effects, watercolour (8 August 2022, midnight and 1.00am)

Fig. 12 – The Farmhouse in Titignano, Orvieto, Umbria. Light effects, watercolour (9 August 2022, 2.00am and 3.00am)
Artificial and natural lights

It is not easy to take explorative graphic notes at night because, in practice, a small light source is needed to shed light on the piece of paper without disturbing the drawer and without contrasting the natural and/or artificial luminous tones that are present (small reading lights that can be attached to the piece of paper are very efficient). Maximum concentration and maximum control over the graphic composition are essential because when you raise your eyes from the faintly lit piece of paper and look into the dark, you need to continually force yourself not to miss some of the luminous vibrations and effects.

It is crucial to be quick, just as it is when drawing or painting during the day, because the intensity of the light varies after a few minutes and changes the visual perception of the whole scene.

In this case, two main elements were the focus of the graphic representation: the background (the sky and vegetation of the surroundings woods) and the unique characteristics of the architectural structure.

The chromatic values created by observing the sky are more opaque, in contrast with the bright values produced by the artificial light inside the farmhouse. In fact, the lights that seep through the windows and doors come from specific light sources and create effects that are constantly changing; sometimes they merge with the surroundings or spread out in a circular pattern on the façade.

Sometimes, when the strong artificial light from inside the farmhouse is combined with the moonlight it almost completely cancels out the vegetation, replacing it with very dark shadow areas. The different chromatic intensities always have to be balanced so that the representations convey a harmonious image of reality at night.

Conclusions

There are many ways to graphically represent the nocturnal values of our architectural heritage. This graphic experiment using watercolours painted on site is just one option - an option that made it possible to intuitively and emotionally capture the effects of nocturnal light on a material. The critical interpretation that takes place during a drawing from life experiment not only increases our awareness of the architecture in question, but also documents crucial material and immaterial data; the latter help us understand that it is important to focus on them, both in the city and in natural landscapes, so as to ensure their enhancement.

Wassily Kandinsky, the late-nineteenth-century, enlightened Russian painter, maintained that colour is directly related to our emotions and that we can successfully use representation to express it. In fact, when we experience a place at night, the buildings and spaces convey spatial emotions that stimulate our senses.

In addition, when we graphically monitor an architecture at night we are able to appreciate hidden parts, elements and characteristics which, sometimes, in certain cases, may go unnoticed.

Today, the digital technologies used to create numerous ephemeral architectural representations render the latter dynamic and interactive. Instead the night provides different images of our contemporary nocturnal landscape, sometimes sharper and sometimes more blurred; these images express the social and cultural identity of the specific historical period to which they refer.

I should not fail to mention the proliferation of digital façades that redefine architecture as a numerical landscape (cit. Introduction Marc Armengaud, Matthias Armengaud, Alessandra Cianchetta). Indeed, all over the world we see gigantic temporal installations that during the night change colour depending on who is sponsoring the evening’s event. They produce many different effects which, now and again, are interesting and respectful, but at times are also visually a little aggressive. They become a social, cultural, economic and political landscape that still remains rather unexplored as a new perceptive frontier.

To graphically interpret an architecture and its landscape using all the analogical and digital systems available, including integrated systems, is just one of the methods we can exploit to develop and design their enhancement in a more sensitive, mindful and informed manner.

Colors in Architecture: Matter and Communication Tool

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Abstract

Rem Koolhaas recognizes two types of colors in architecture; ones that are linked to the raw materials and their natural physical appearance, and the ones that are layered on and have the ability to change appearance. Naturally, the use of one or the other involves a different design approach. In the first case, the search of the architect is based on a material choice, on the specific qualities needed to bring out certain aspects of the architectural project.
In the case of Frank Gehry for example, the priority is the plasticity aspect along with the idea of movement through the use of convex, concave and angular shapes. The materials change depending on the project, each material is chosen to emphasize the complexity of the shapes for his buildings. Mario Botta favors almost exclusively the use of visible natural materials like stone and bricks, in order to enhance form. His choice in material is linked to the search for depth and thickness of the wall. Tadao Ando focuses his architectural design efforts on light and matter. Ando is a master in the technique of the reinforced concrete, and it is a way for him to connect back to traditional Japanese architecture, monochromatic with an infinite variation of shades and tones.
Jean Nouvel, differently, prefers the use of the applied color. The design strategy changes drastically as it becomes an additional part of the architectural project. In each work, Nouvel investigates ways to emphasize the genius loci, coming up with concepts that are able to evoke emotions through the poetic of color that "is either intensified, the monumentality of black heightened by the stark introduction of red, or else tends towards an immateriality". For Will Alsop, the use of color is strongly linked to his design process, developed over the years but that almost always includes collaboration with artists. His view on architecture is similar to that of a sculptor, colors are a way to express irony and cheerfulness. When imagining the work of Norman foster, color might come as an afterthought but, in his book *Norman Foster: 30 colours,* one is perhaps surprised to find that the previous statement is not entirely true. Foster's use of color is definitely moderate and sparks an interest for where and how it will be used. Perhaps Paul Overy best describes Foster's use of color as the human component, the element of nature, opposed to the culture of materials and structure.
By comparing these two uses of color it is clear to see how one is more intentional than the other but the results of both, for different reasons, still resonate with the observer as they both achieve the architect's wish to communicate emotions.

Keywords: Architecture, materials, communication, design process, form, color

Introduction

The Latin root of the Italian word *colorare* (to color) is to cover, hide, conceal, to mask. Therefore, the act of applying color to a surface is a coating action. Naturally, the meanings of the action *colorare* and its significance can be numerous. The role of color in architecture is not marginal, color in architecture does not only mean paint on the walls, once the whole building has been completed. The choice of color in architecture has the ability to conceal and at the same time to highlight the content. It can be understood as the confinement of what is unpleasant, but also the projection of something of the highest value, both material and metaphysical. The more conscious design approach to the use of color and of materials, makes the chromatic and tactile components important elements in the compositive language of architecture (Braham, 2002). Colors, materials

and faces, their composition and surface treatment contribute in a profound manner to define the identity of designed spaces and buildings.
Rem Koolhaas summarizes numerous possibilities that color presents to architecture by recognizing two main tendencies (Koolhaas *et al.*, 2001). He recognizes two types of colors in architecture; one type, linked to the raw materials and their natural physical appearance and coloration, and the other, where color is layered on and gifts architecture the ability to change its appearance. Naturally, the design approach varies depending on which type of color the architect choses to utilize.
This study wishes to further analyze Rem Koolhaas stance on color starting with the comparison between other architects and their works, that typically prefer to use one type of color over the other. The comparison between different architects and their works will enforce Koolhaas's views on the matter allowing a further understanding of color as an important aspect and tool of the discipline of architectural composition rather than simply being an afterthought (Schultz, Herrmann and Wiedemann-Tokarz, 2019). For each color type, three architects have been selected and for each of them, a specific architecture, representative of their work, has been briefly analyzed. For the first typology, architects Frank Gehry, Mario Botta and Tadao Ando have been selected, for the second, Jean Nouvel, Will Alsop and Norman Foster.
Even though the architects chosen are internationally recognized and have constructed projects all over the world, the study wishes to address only European architectures, between the years 2000 and 2010. Color and context are both part of the composition disciplinary and are usually correlated. This correlation does not necessarily translate in the use of traditional materials or "color history" of specific places but, even when the choice of the architect is to discard any type of correlation, the relationship between artifact and context is not one sided. Just as context can be a source of inspiration for the concept of a building, the context is also influenced by the constructed buildings, whether the design approach is of continuity or contrast.

Materiality
In the first case, the three architects selected use specific material choices to convey their idea of architecture. The materials are always selected because of their explicit qualities and colors needed to bring out certain aspects of the architectural project.
In the case of Frank Gehry for example, the architect's priority is the plasticity aspects along with the idea of movement (Mattie, 2015). This is achieved through the use of convex and concave volumes, in contrast with more sharped-angled rectangular volumes, staples of his architecture. His rejection of the rectangular shape is in contrast to the believes of the iconic examples of modern and contemporary architecture.

Fig. 1 – Frank Gehry, MARTa, Herford, Germany, 2005

The materials change depending on the project, each material is chosen to emphasize the complexity of the shapes for his buildings. The materials chosen are very often selected from local traditions, but one material in particular, thought of as an enhancer of the convex and concave spherical volumes, is the use of reflective metal, either titanium-zinc or stainless steel.
This is very evident in the MARTa project (Fig 1) of 2005 where the materials used are precisely local dark red brick, contrasting with the white plaster core of the historical, preexisting building and the stainless steel roof panels (Pagliarini, 2010). The red-orange brick facades, along with the steel, grey reflective roof, give the idea of the soft bends of the adjacent River Aa, the highway turns of the Goebenstrasse, as well as the nearby train yard, only interrupting to create an opening for the entrance. Once inside, the contrast with the white plaster straight walls and 90-degree angles of the former textile factory of 1959, left almost intact by the architect, is of high impact. Despite the somewhat limited color palette, including only the red-orange of the bricks and the gray of the roof panels, the extraordinary dynamism of Gehry's designs is emphasized thanks to the light, almost white reflections and the dark, black projected shadows of the curved and concave shapes of the museum.

Fig. 2 – Mario Botta, Werner Oechslin Library, Einsiedeln, Switzerland, 2006

Mario Botta favors almost exclusively the use of visible natural materials like stone and bricks, in order to enhance form. This usually translates in architectures that have more earth toned colors; light and drack reds, oranges, burnt and regular siennas, soft whites, warm grays. His choice in material is linked to the search for depth and thickness of the wall. This return to a tectonic tradition gets reinterpreted by Botta and utilized for the creations of his architectures. In this sense, it is a profoundly "classical" architecture (Cappellato, 2008). The wall is for Botta an important element, not only static and technical but a spatial entity. For this reason, his works convey feelings of durability and solidity, only achievable through the textures of such materials. Furthermore, the wall for Botta is thick, it is a testimony of the deep separation between inside and outside, with openings carved to model light.
The Werner Oeschslin library (Fig. 2) is built adjacent to a Benedictine Abby of 934, a stop for pilgrims on their way to Santiago de Compostela. The building is made of red, light and dark stone from Verona, making it seem like a continuation of the hill. The wall facing the valley has a straight vertical cut on which the entrance opens. The wall facing the mountain landscape, appears as a convex curve, designed explicitly in order not to harshly contrast the hill behind. In this case both walls are not an element that closes, but they are understood as tools, screens that project towards the outside the symbolic valor of the building.

Tadao Ando (Tadao Andō Architect & Associates and Fernández-Galiano, 2022) focuses his architectural design efforts on light and matter. Ando is a master in the technique of the reinforced concrete, and it is a way for him to connect to traditional Japanese architecture, constructed almost exclusively by highly textural materials of vegetal nature, like wood, bamboo and thatch mats. The sensation transmitted is more or less monochromatic, with an infinite number of shades and tones. While the colors of traditional Japanese architecture are soft, warm earth tones, Ando almost exclusively utilizes light, cold grey concrete and by leaving it exposed, and showing the veins and nodules of the wood framework he achieves similar textures. Exposed concrete is the most modern and suitable solution to accommodate Ando's designs, it makes it possible to satisfy both technical-engineering and economic needs (Bosker, 2017). Tadao Ando's architecture shows a clear trend towards customized solutions and uniqueness of surfaces.

For the AD House (Fig. 3), the clients request for privacy inspired the "invisible house" concept that translated in a building partially buried in the middle of the plot, enclosed by a wall of trees. The building is constructed by a grid of axes that define the different indoor areas and courtyards of the house. Both the partitions and monolithic slabs of the house are made in perfectly executed light grey concrete. The exposed concrete cast in place leaves ample expressive space. Only the volume of the entrance tunnel does not follow the grid and its five-meter height makes it the only visible element of the house to the outside. It is also the only element of the house to have a light grey metal panel cladding. The colors of the two materials are very similar but their reflective properties make them appear slightly different.

Fig. 3 – Tadao Ando, AD House (Invisible House), Ponzano Veneto, Italy, 2004

Colorare

This second category explores examples of architects who chose to use applied color in their architectures. Just like in the previous category, the use of color is extremely different and personal for each architect. Each time color is used to convey something different and it translates in three very different architectures that otherwise could not have been compared.

As Jean Nouvel prefers the use of the applied color, the design strategy changes drastically as it becomes an additional part of the architectural project. In each work Nouvel investigates ways to emphasize the genius loci, coming up with concepts that are able to evoke emotions through the poetic of color that is either intensified to achieve monumentality, through the use of the colors black and red, or else tends towards an immateriality with more neutral colors, white and transparent (or semitransparent) surfaces (Mattie, 2015).

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The Kilometro Rosso (*'Kilometro Rosso' - Parc scientifique et technologique*, no date) (Figure 4), is a kilometer long billboard adjacent to the Milan-Venice expressway near Bergamo. On the highway side the project presents a tall, 10-meter-high wall cladded in red lacquer-stained steel sheets. The monumentality of the architecture is clear by the extensive size of the wall, but especially thanks to the use of iconic Ferrari red. The wall creates a visual barrier between the research center hidden behind and the chaotic and loud nature of the motorway along with becoming an important visual landmark for the area. The bright color red is both a way to stand out as well as an homage to the prestigious Italian company that makes breaks for many luxury and competition automobiles and motorcycles, including Ferrari. The color red bends at the base of the wall and also invades and tints the one-kilometer-long parking podium, making the wall appear even taller. The vibrant red along with the kilometer long 10-meter-high wall give the scientific and technology center, hidden behind, a strong identity that makes the commercial-industrial ensemble stand out from any of the other numerous industrial developments in the Bergamo area.

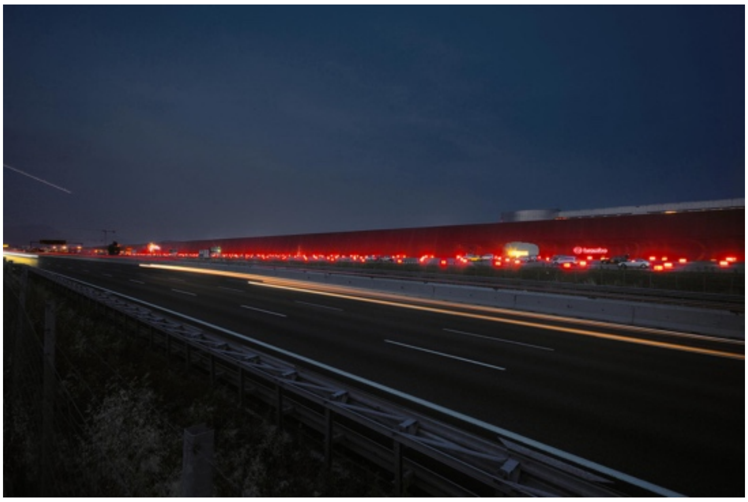

Fig. 4 – Jean Nouvel, Kilometro Rosso, Bergamo, Italy, 2007

For Will Alsop, the use of bright and saturated colors is strongly linked to his design process, developed over the years but that constantly includes collaboration with artists (Orlandoni and Porter, 2016). The use of color in architecture requires a non-subjective understanding of the color itself and at the same time, the progressive conquest of a strong expressive freedom. The first can be achieved through rigorous phenomenological observation and the second through an exercise in the art of color that recognizes the difference between arbitrariness and freedom. This way, the use of color can prove effective in an architecture that knows how to interpret the needs of today's men. According to this point of view, it is necessary to combine constrictions and freedom in architectural chromatism, just as the artist intends to do in the context of any visual art. Alsop's view on architecture is similar to that of a sculptor, colors are a way to express irony and cheerfulness. The result is an architecture immersed in a timeless dimension in which light molds matter and color reveals the beauty of shapes and spaces.

The Chips project in Manchester (Figure 5) is no exception. The building resembles "three fat chips stacked on top of each other". The "chips" are three identically sized staggered volumes, approximately 100 m long and 14 m wide. Altogether the chips form a building with an elevated ground floor and eight levels, housing 142 apartments. Each chip is cladded in a composite wall of a different color and then covered in newspaper print text to homage the industrial heritage of the context. The ground "chip" is of a deep brown-red color, the middle chip is brown-black and the top chip of a bright orange-yellow. On each of the volumes, cubed subtractions have been made in order to create balconies, that have then been painted with saturated, almost neon colors such as

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green, magenta, purple and yellow to further “cheer up” the façade as they almost appear like colored drippings.

Fig. 5 – Will Alsop, Chips, New Islington, Manchester, UK, 2009

When imagining the work of Norman foster, his use color might not come up as a major aspect of his practice but, in his book *Norman Foster: 30 colours (Overy, 1998),* one is perhaps surprised to find that the previous statement is not entirely true. Foster’s use of color is definitely moderate and sparks an interest for where and how it will be used. Perhaps Paul Overy best describes Foster’s use of color as the human component, the element of nature, opposed to the culture of materials and structure. A similar approach can be seen in the Centre Pompidou, the most famous example of this type of color use, where it brings to light something more, something occult and which is often even hidden: the functionality of the technological apparatus.
Perhaps in a much more discrete way than the Pompidou, for the fourth building on the Imperial Collage’s South Kensington campus designed by the architect, the Imperial College Faculty Building (Fig. 6) presents itself as a simple four-story high box. The building rests on an existing deck that has been elevated in order to accommodate the plant area and the electricity substation as well as two stories of parking. The façade is cladded by a system of blue opaque and transparent panels in three shade variations chosen by the artist Per Arnoldi. The façade is interrupted on the ground floor by a gentile ramp that cuts across the building diagonally in order to create a shortcut through campus as well as opening up a view of the Queen’s Tower. On the inside, the ramp is lined by rows of columns that thanks to their red paint are also visible on the outside, through the more transparent façade panels, adding another level of vibrancy to the façade itself and the adjacent court.

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Fig. 6 – Norman Foster, Imperial College Faculty Building, London, UK, 2004

Conclusions

By comparing these two uses of color it is clear to see how both, for different reasons, still resonate with the observer as they equally achieve the architect's wish to communicate a specific type of architecture. It is important to notice that even if the two categories exist, as demonstrated with these case studies, they may not always be so clear cut and separate.

There are definitely architects that belong to the first typology of color use whose work is defined by the almost obsessive use of one specific material and, as a consequence, one color, like in the case of Tadao Ando, there are no material transgressions, and no applied color is never used. While still belonging to the first typology, Mario Botta's architecture presents itself with a few more chromatic differences. Though the element of color is still strictly linked to stone materials, they tend to offer more color and shade variations, ranging from light and dark reds, oranges from the bricks and whites and grays from stones. His architectural research is about solidity, depth and thickness, qualities conveyed only by the materials in question. Whether it be the black Gneiss and white marble of the Mongo church, the red Prun stone of the Petra Vineyard or the red Verona stone of the Werner Oeschslin library, Botta's color palette is strictly based on the choice of material for each project. Frank Gehry on the other hand does occasionally introduce color to his projects, by applying colored plaster like in the Vitra Headquarter in Basil, Switzerland where some of the plaster elements of the facades are painted blue, yellow and orange. For the Bodegas Marques de Riscal (Viva, 2006) in Eltziego, Spain, Gehry introduces color on the roof panels by selecting pink titanium, gold titanium and mirror like stainless steel to reflect the colors of the winemaking firm. Once again, the color is not applied on the material as a cover, it is incorporated in the material itself.

Analyzing the typology of applied color, Will Alsop can be defined as a "purist" on the exact opposite spectrum as Tadao Ando. One of Alsop's main themes in his architecture are bright, lively colors and the expression of a sculpture like approach to architecture, where the use of color is never neglected but is rather an essential aspect of his designs. Lastly, Jean Nouvel and Norman Foster's use of color is more accurately described as a mixture of the two categories. Materials like concrete, steel and glass characterize both architect's work, producing strong buildings in character and composition while the role of color is designated to disclose certain specific aspects of each architecture.

Even if these categories exist and are distinct to one another, they are not exclusive and one most certainty does not necessarily eliminate the other.

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Exploring the colors used in renovation of interior space: a survey on post-use of higher educational classrooms

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Abstract

As the previous study shows, the colours of architectural environments have physiological, emotional, and cognitive impacts on students. Mounting evidence indicates that the color of classroom influences students' performance. When it comes to the renovation of educational interior space, colors should be taken into consideration. This article focused on two built higher educational inner space: the architectural college of University of Florence and the smart classrooms in Tongji University. The history of Santa Teresa (Universita di Firenze) dates back to the year 1620 and was donated to Paris by M Francesca Guardi in memory of St Teresa. It was not until 1984/85 that there was a proper oversight of the campus renovated from a prison. As for the history of South building in Tongji university, it is one of the first teaching buildings on campus, built in the year 1953. The educational interior space in both two cases are renovated for new requirements and designed with different colors.

The design team also made a survey on collecting the post-use feedbacks within students in Tongji University, which gave us an objective view of the effect. The main methods are literature study, field research and questionnaire. By reviewing the related studies and reports, how the colors impact students are summarized. The whole effect of the teaching environment can be shown in field research. At last, combined with the post-use information, the final conclusion contains four main points: Bright and lively colors can improve attention and concentration of young people; Colors can be used to compare old and new in the renovation of historical environment; Colors can be used as the logo color of each space; Choosing the appropriate color block size according to the teaching content can create different spatial effects. The purpose of exploring the colors used in renovation of interior space is to give some inspiration from an architectural angle to designers and artists, and also whom interested in colors and environment in eastern and western countries.

Keywords: colors, educational space, interior environment, renovation, historical buildings.

1 Introduction

In 1880, the Italian Institute of Architects produced a set of maps covering more than 20 colors, and established the main color of "Turin Yellow" for the urban architectural colors of Turin. In the 1930s, Toshio Hosoya in Japan discussed the influence of the teaching environment on students from the natural, social and spiritual levels, and published "Educational Environment". In 1965, the Architecture Research Laboratory of the University of Michigan conducted environmental research on the campus for six years, providing a theoretical basis for future research. In 2001, American scholar Michael J. Crosby published "Class Architecture", which discussed the new architectural situation of more than 40 schools that meet the needs of campus space development. In 2006, the United States conducted practical research on the color of architectural space, and proposed the view that architectural design should be combined with color psychology. China's attention to architectural color has grown rapidly since 2000, and relevant scholars have focused on urban color planning and research on architectural color.

The previous study and repost found that student perceptions of their learning environments highly relied on spatial attributes (such as room layout and furniture) and ambient attri-butes (such as temperature and air quality). The potential value of effort is to improve design, management and maintenance for higher education classrooms, while also providing guidance about beneficial

changes to implement(Yang, Becerik-Gerber and Mino, 2013). Among many elements that make up the physical environment, color can stimulate the imagination and emotion of people in this space because of its unique perceptual characteristics. It can be seen that color design is of great significance in the composition of the physical environment of the classroom.
The purpose of this paper is to explore the color preferences of college students in the physical environment through the use of color in two college classroom renovation projects, and to provide help and basis for future color selection in educational space.

2 Materials and Methods

Our research is based on the literature investigation, qualitative analysis of direct field observation and questionnaire method to investigate students' post-use evaluation. The interior regeneration strategies about colours are extracted from these cases.

2.1 Literature Review of Cases

2.1.1 Santa Teresa (University of Florence)

In 1992, the old prison structure of Santa Teresa was fully transformed into an educational center, with its already existing large space, suitable for accommodating a large number of people. The renovated space include teacher studios, classrooms and spaces dedicated to student learning. Traces of the historical prison function of the central institution remain, and the prison cells have always been there.

Dating back to 1620, it was donated by Maria Francesca Guardi to a monastery in memory of St. Teresa, churches and monasteries designed by Florentine architect Giovanni Coccapani. The abbey was suppressed by the French government in 1808, but eight years later it was restored and used partly as a municipal school. In 1865, it was completely suppressed and converted into a preventive prison. Consequently, the factory underwent further renovations: between 1866 and 1897, three new buildings were added to the convent garden, the development of which parallels via della Mattonaia. The central building was used as a prisoner's cell, while the side bodies included carpentry, shoe repair and machine workshops. Until 1984/85, the prisoners were transferred to the new Soliciano prison, while the former prison was awarded to the University of Florence by the Municipality of Florence(Fig.1).

Fig. 1 – previous situation of Santa Teresa

2.1.2 Smart Classrooms in South Building (Tongji University)

The South and North Teaching Buildings were built in 1953 and 1954, functioned as the main teaching buildings on the Siping Campus in Tongji University. They were originally designed symmetrically with Chinese traditional big roofs and white marble handrails, and decorated with carvings and painting on the beams. To pursue a lifestyle of simplicity which was popular at that time, the buildings were eventually completed with terrace roofs, overhanging eaves and brick tracery parapets. For the base of the buildings, cement dressing was used for an effect of sumeru style, and the plain red bricks were chosen for the outer walls(Zhou Hongwu, 2019) (Fig.2). The early classrooms are used for basic course teaching, general courses of various majors in the entire campus. The interior space characteristics are shown in Fig. 3.

Fig. 2 –South building facade

Fig. 3 – interior space of classroom in South building

2.2 Field Observation

Santa Teresa was renovated by Breschistudio. The design practice was founded in 2009 by Professor Alberto Breschi, Claudia Giannoni, and Serafina Amoroso, who left in 2012. The renovated School of Architecture preserves the structure of the historic prison, but at the same time highlights the contrast between old and new with modern materials and bright colors. Because the audience of its teaching content is the students majored in architecture and design, a large area of bright colors are used to highlight the space characteristics, so that the interior space is full of individual characteristics. See Fig. 4 for the reformed teaching function division.

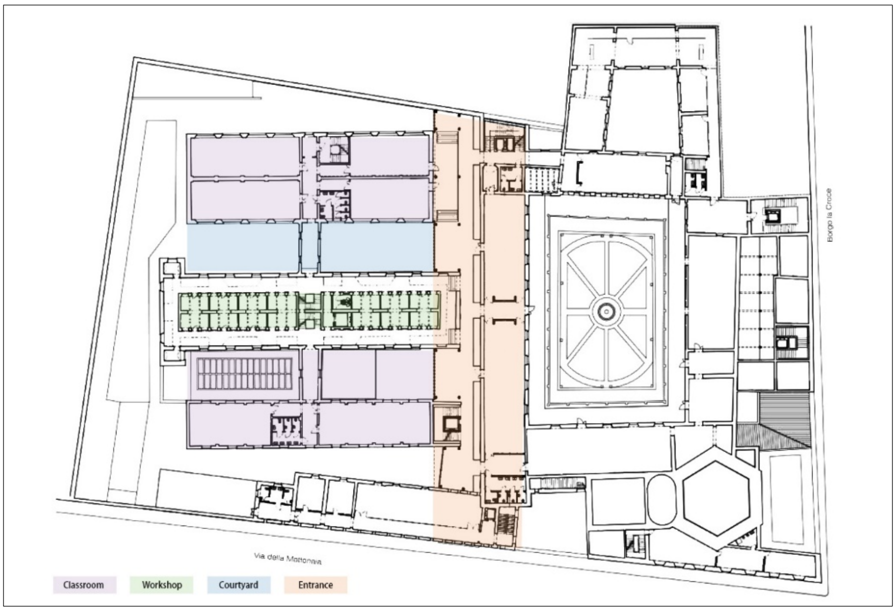

Fig. 4 – plan of function division

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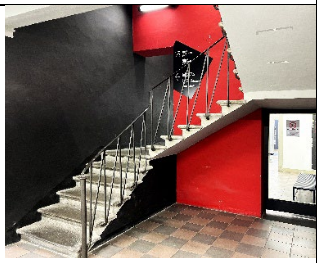
As for the use of interior colors, it is mainly a large colored wall of black, red, blue, yellow and green. It forms a strong contrast with the closed system of the original prison. It has both a sense of conflict and a sense of design, which not only gives people a contrast between the old and the new, but also plays a different prompting and identifying role. Representative colors and transformation location with photos are shown in the table1.

Table 1: Applied colours strategies

Location	Entrance	Classroom lobby	Meeting room	Rest place
Photo				
Colour	light yellow	dark blue/green/light yellow	red	Red/blue
Location	Corridor	Main Stairs	Elevator	Toilet
Photo				
Colour	black/red	black/red	blue	black/red/yellow
Component	Door	Dome	Logo	Equipment pipeline
Photo				
Colour	blue	red	blue	green

Source: Author

In 2020, according to changes in teaching content and requirements, the ordinary classrooms on the fourth floor of the South Building will be transformed into smart classrooms. The principles of renovation design are: wisdom (intelligent technology and teaching requirements are deeply integrated), creativity (innovative design improves classroom quality), culture (highlights Tongji characteristics and cultural connotations), and individuality (satisfies individual needs). Design strategies include adjusting the classroom space layout (Fig.5), unifying the layout of multimedia equipment, adjusting the light and presenting the historical features. The content of the color transformation is as follows. Selecting classroom logo colors from the campus landscape: sky blue, sycamore leaf yellow, lilac purple, grass green, and red of historical library as the main colors and spray them on the aluminum alloy trim of the classroom. Surface and furniture color: basically wood color, coffee color, black and white color. Representative colors and transformation location with photos are shown in the table 2. The whole classrooms(A\B\C) are renovated with elegant and natural decorations.

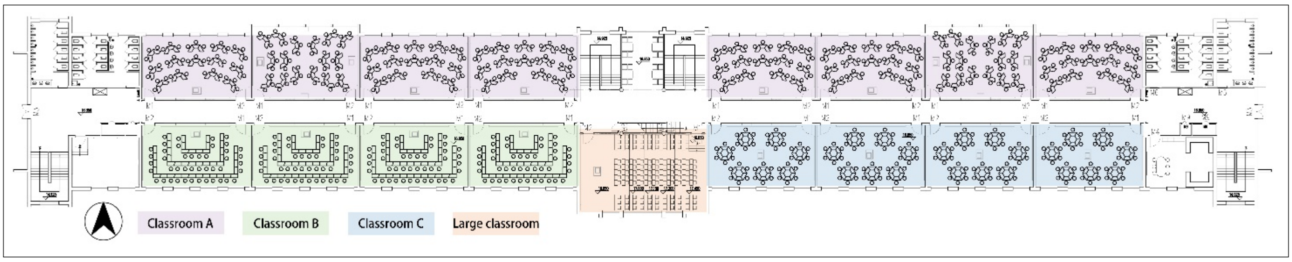
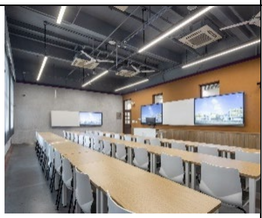
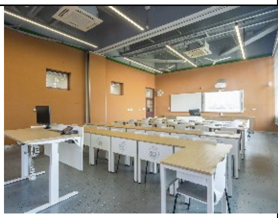
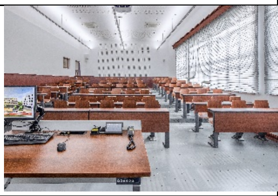
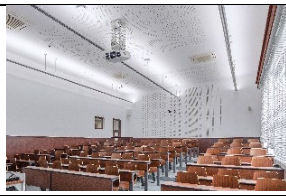
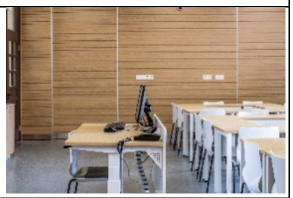
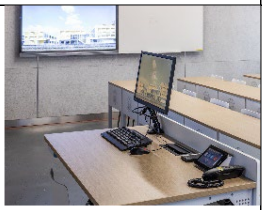
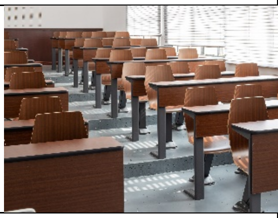
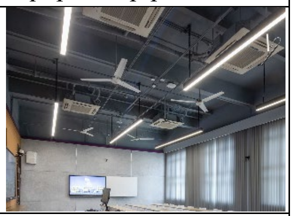


Fig. 5 – classroom layout plan

Table 2: Applied colours strategies

Location	Classroom A	Classroom B	Classroom C	Rest place
Photo				
Colour	grey/ yellow	yellow	yellow	grey/green
Location	Corridor	Large classroom	Ceiling	Side wall
Photo				
Colour	green/red	red-brown	white	yellow
Component	Multifunction device	Furniture	Logo	Equipment pipeline
Photo				
Colour	black	red-brown	green	grey blue

Source: Author

3 Results

Post-assessment questionnaires were distributed after the renovation in fall 2020 semester. Judging from the feedback received, the students were generally satisfied with the transformation effect. A total of 525 questionnaires were distributed, including undergraduates, graduate students, doctoral students and teachers, and 522 valid questionnaires were recovered. The statistical results are credible. The gender and grade distribution of the respondents are shown in Fig.6. The statistical results related to the satisfaction of the color transformation in the questionnaire survey are shown in Fig.7.

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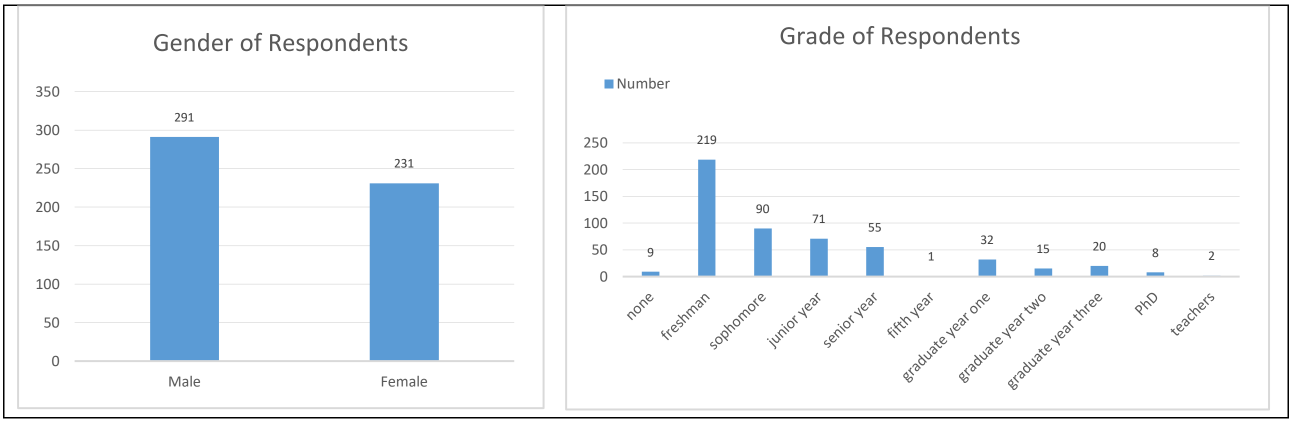

Fig. 6 – statistical information about respondents

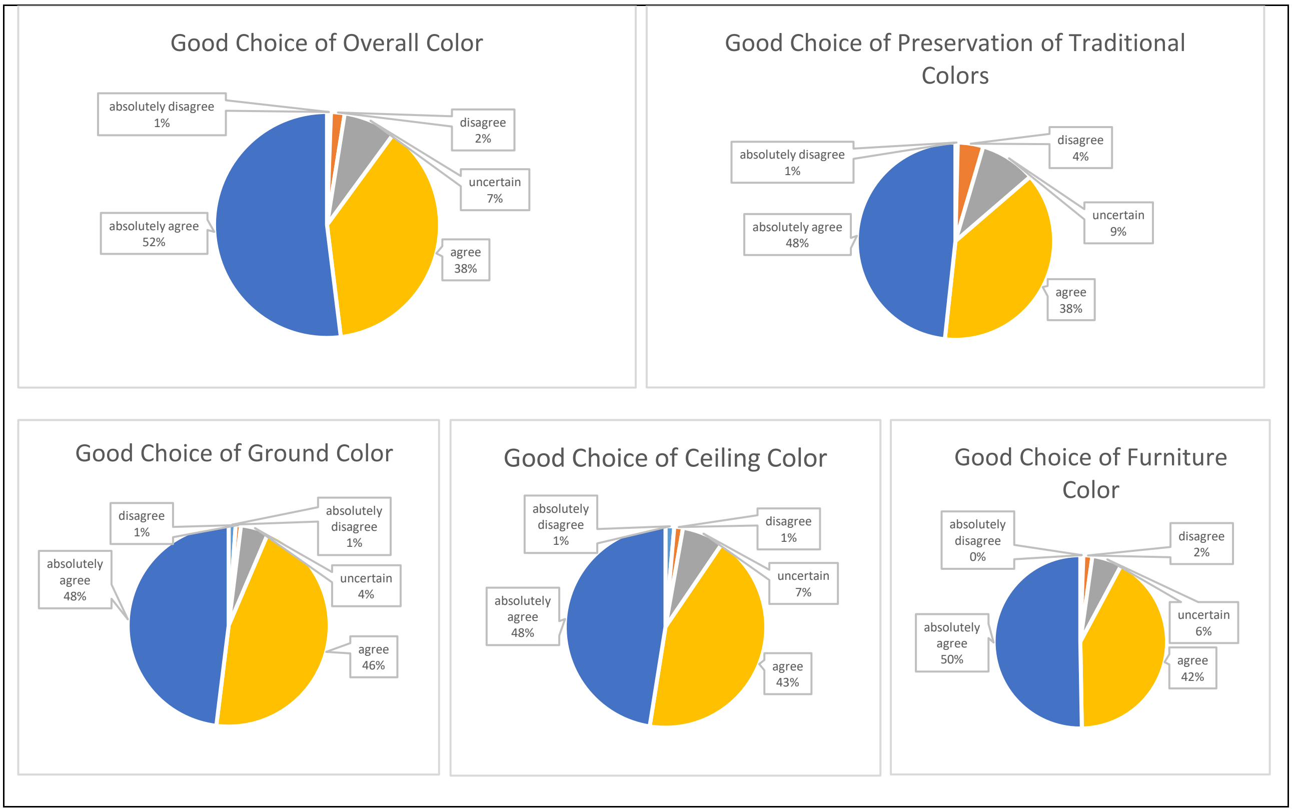

Fig. 7 – statisfication about applied colors from respondents

4 Discussion

Our data analysis suggest that the main students are satisfied with the effect of this color transformation, and the starting point and effect of this color transformation are convincing. Different colors have different effects on the development of teaching. In a class, teachers usually use corresponding teaching skills according to the concrete objectives and content, such as free discussion, independent learning, cooperative learning, etc. Different teaching skills have different requirements for colors. For example, the design of warm colors can well mobilize students' autonomic nervous activities, stimulate inspiration, and promote divergent thinking, but it will produce a certain sense of urgency, which is not suitable for rigorous and meticulous learning activities. The cool color design can make the learners maintain a good level of studying, but it is difficult to mobilize the students' autonomic nervous activities, which is not suitable for the teaching activities of innovative thinking (Latini, Di Giuseppe, D'Orazio and Di Perna, 2021).

As mentioned above, the function of the Smarter Classroom in the South Building of Tongji University is to teach general courses, which is different from the training content of design and creative thinking aimed at the School of Architecture in University of Florence. Therefore, the color selection of classroom renovation in South building mainly came from the existing campus environment, the whole mild color system is suitable for college students to concentrate on their studies. While in Santa Teresa, bright colors can stimulate people's creativity.

Different students have different color preferences, which are affected by students' age, gender, and geographical differences. Generally speaking, primary school students prefer warm and pure colors. Adolescent students and adult students prefer blue and other elegant colors. As they grow older, the elderly students prefer red instead of blue conversely. The color preference of college students is closer to that of adults. In a study by Sevinc Kurt1 and Kelechi Kingsley Osueke, they conducted a color preference experiment on the interviewed group aging of 17-24, and obtained the following results. Respondent’s least favorite color: brown (26%), orange (21%), and gray (13%) comprise the majority of negative responses. Respondent’s favorite color: blue turned out to be highly favored with a total count of 136, followed by green with 92, by yellow with 83, and by red with 42 respondents favoring them, respectively. College students also have long-term rebellious thoughts and the desire to pursue youthful style, so they need more changes and colors to guide their emotions. Unity and variety are the opposite of each other. The mark of good color arrangement is knowing where to stop between these extremes (Kathy, 2003). The need to know the effects of colors on moods of individuals is very essential for architects. In most cases, the use of appropriate and/or correct colors would increase the functionality of that space.

Through field observation and post-use evaluation questionnaires, we have found that in the renovation of college classrooms, design starting point should be the historical environment of the building itself, and choose the color that match the curriculum requirements and the students' preference. Both the observed cases and the quantitative data indicate that our results are consistent with the existing literature. This study only conducted a later questionnaire survey on the classroom renovation of Tongji University. At this stage, due to the epidemic situation, it is impossible to conduct a supplementary survey on Santa Teresa. From the feedback of the current users, most of the students are satisfied with the renovation results in Santa Teresa. Therefore the sample limitation did not affect our findings. In the future, we will continue to pay attention to the color selection of the teaching space, and widen the research focus from college students to teaching spaces of all ages, so as to provide more ideas for the application of interior colors and the color research field of historical building renovation projects.

5 Conclusion

Judging from the two college classroom renovation projects, the requirements of colors for different teaching contents and effects are various. When a historic building is transformed into an interior space suitable for college students, the choice of color can be considered from many aspects. The following points can be considered in future design:

- bright and lively colors can improve attention and concentration of young people;
- colors can be used to compare old and new in the renovation of historical environment;
- colors can be used as the logo color of each space;
- choosing the appropriate color block size according to the teaching content can create different spatial effects.

List of images

Fig. 3 – interior space of classroom in South building (Source: Author)
Fig. 4 – plan of function division (Source: Author)
Fig. 5 – classroom layout plan (Source: Author)
Fig. 6 – statistical information about respondents (Source: Author)
Fig. 7 – statisfication about applied colors from respondents (Source: Author)

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Experience of place: colour and lighting design methods in the process of inclusive housing projects

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Abstract

The periods of confinement that we have experienced have highlighted the proven impact of the quality of living spaces on their occupants. While the health crisis has been at the heart of many debates in recent years, it has only served to highlight the issues at stake and to accelerate research into the quality of life in collective housing. The notion of quality of life often translates into the ambition to build responsible buildings, responding to issues of air quality, water quality, energy saving (etc.), however, the design of visual environments must be considered in the same way as the other intrinsic characteristics of the dwelling as elements contributing to meeting the expectations of inhabitants in terms of health and quality of life for all.

Keywords: Light design, Colour design, Visual comfort, Property developer, Collective housing.

I. Introduction

1.1 Issues addressed

Currently, 31.6% of the French population lives in a collective dwelling, i.e. nearly 21 million people (Henri Albertini *et al.*, 2018). At the same time, around 12 million French people are affected by a disability, including 1.5 million with a visual impairment and 850,000 with reduced mobility, due to various pathologies, life accidents or age (Mormiche, 2001). Similarly, the increase in life expectancy is indeed a warning factor that should challenge us in our approach to designing an inclusive space, because in 2050, metropolitan France will have between 58 and 70 million inhabitants, by which time more than a third of the population will be over 60 years of age, which will require numerous adjustments to our daily living environment (Brutel, 2002). Moreover, in recent years, home care has been preferred to institutional care, especially for people with a slight loss of autonomy (Kubiak, 2012), so for all these people, the positive and safe perception of the daily environment must become an important issue for designers of collective housing. Thus, it is essential to take into account the parameters of colour, light and materials in this type of environment, as factors of atmosphere and comfort of use. These elements have led us to question how professionals of collective housing take into account the characterisation of the CLM (colour-light-materials) approach in the design of inclusive common spaces, where plural human needs must be at the centre of the reflections.

1.2 Reassessment of standards

For many years, the authorities have placed man and his pluralitý at the heart of many laws that come to life within new architectural projects. However, these laws are very often set up and governed by recurrent and unwavering norms, averages and conformities; yet, if we stick to the strict observance of these, as man does not respond to any average it is obvious that many gaps remain. Furthermore, in the literature on environmental factors, the subjective part in the assessment of environmental factors is often mentioned, but there are very few indicators that refer to this. Mudri (Mudri, 2002) states that in studies using interviews and observations, the dimensions of the personalitý and disabilities of the subjects have generally not been studied in detail and the subjects are therefore considered 'average'. As a result, it goes without saying that strict adherence to these rules and averages does not guarantee the success of an architectural project, particularly in visual ambience design.

2. Transdisciplinary approach

2.1 Research context: transdisciplinarity as a lever for social innovation.

Today, we note that more and more designers in the field of architecture are becoming aware that the quality of life in collective housing requires the emergence of interdisciplinary designs and are committed to placing human concerns at the heart of the issues. Therefore, our study presents a design method combining collaborative and evolving expertise for the benefit of tomorrow's inclusive housing. Attentive to emerging demands, the company Sobrim, an expert in Basque real estate development, took the initiative in 2018 to create a multidisciplinary centre of expertise. Its ambition is to go beyond the strict field of property development, as the methodology applied to this new approach, known as Haranam (SOBRIM - HARANAM), is experimental, global, transversal and multidisciplinary. It is based on a synergy of work between experts from different fields. During dedicated days, doctors, physicists, doctoral students, building and human science experts are invited to discuss the complexity of the issues at stake in order to come up with concrete solutions and specifications that meet the expectations of tomorrow's housing.

The study proposed here questions the way in which doctoral research in CLM is taking up these new design methods. The answers and methodologies provided are anchored in a research-creation approach, addressing an interdisciplinary design protocol, conducted in the real estate development sector. To this end, we will present a case study and a design protocol in terms of colours (colour counter-types), lighting (characterisation of light) and soundings (characterisation of feelings), with the aim of accompanying designers in a process of designing interior visual environments and chains of movement that are truly adapted to the conscious and unconscious needs of their inhabitants.

2.2 Research-creation and creation-research in colour, light and matter.

In the literature of cognitive sciences and psychology, there is little research on the role of colour in its relationship to space and in particular in the spatial orientation of people. However, we know that a visual environment adapted (Damelincourt *et al.*, 2010) to the pathologies of people with disabilities has positive effects, but must respect a certain number of criteria such as an appropriate amount of light, contrast and spatial distribution. Various design factors can enhance or hinder the human response, and weaken environmental visual cues. We therefore hypothesised that colour in the architectural environment of multi-family dwellings could support spatial location and orientation, particularly for people who are disoriented, less responsive to conventional signage systems (Bay and Fayolle, 2020) or have certain age-related visual impairments, (see Figure 1).

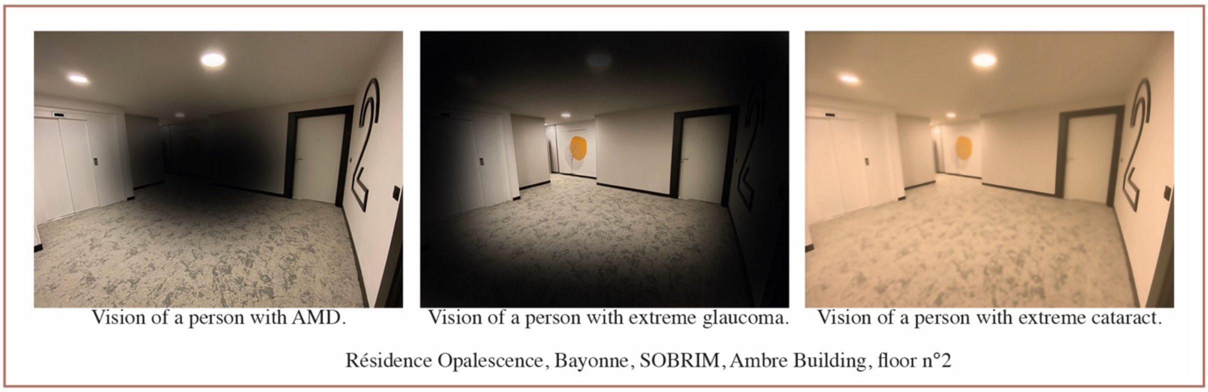

Fig. 1 - Illustration of age-related visual pathologies.

In doing so, this empirical approach will hopefully lead to a reflection on colour in collective housing environments. Inherited from hygienic and standardised norms, we note, even today, that few works integrating colour are the object of a voluntary approach. The choice of colours and materials often depends on the tastes of the project manager and the usual validation of the client,

but what seems to be a secondary issue is in reality a key point in the evaluation of the success of an architectural project. The results of this study will allow the development of a creative protocol that will help the developer to design visual environments that are adapted to the needs of all inhabitants.
The main results expected from this study are:
1.To improve the analysis and interpretation protocol for defining comfortable visual environments.
2.To develop tools to simulate the lighting environment in the design phase of the programme.
3.Facilitate the integration of the results of this study by professionals.

3. Methodology of analysis and creation

3.1 Colour-material, colour-light

The protocol presented is based on a combination of chromatic expertise (colorimetry) concerning the choice of materials, textures and finishes, with an emphasis on colour for its plastic character; and lighting (light characterisation) concerning the quantity and colourfulness of light, with particular emphasis on different colour temperatures. This study focuses mainly on the chains of movement, i.e. the common spaces and the interior horizontal circulations. Indeed, the visual atmosphere of these spaces must create a feeling of welcome, visual comfort and safety for all users, of all ages, day and night. The method used will therefore serve to create coherence and harmony between the exterior landscape treatments and the interior colour and light treatments in order to create an intuitive and inclusive chain of movement.
The protocol and analyses presented were carried out between April 2019 and June 2022 on the site of the "Opalescence" residence in Bayonne built by the property developer SOBRIM (Basque Country, France).

The method was divided into three stages: capture, creation and feedback:

3.2 Step 1: Recordings

The first phase consisted of collecting photographs of the construction site over a period of 8 consecutive hours, the inventory of the existing situation being an essential phase before any project. Equipped with cameras, this preliminary analysis was accompanied by a walk around the site. Photographs cannot faithfully reproduce the colours of a palette. However, they are essential graphic documents for memorising, visualising and disseminating information (Lenclos and Lenclos, 2016). Most colour studies use photographic investigations to support colour surveys. In our case, photography was used in two approaches, one aimed at establishing an inventory of the surrounding urban colours and forms, the other a colour and light diagnosis to judge the appearance of the site under cyclical light conditions. This step was a means of transcribing and analysing the experience of a space.
The second step was to reference the colours of the site using countertypes. In our study, the colour survey consisted of observing the colours of the environment and the architectural elements surrounding the project and comparing them to reference colour samples. Here we used the colours of the NCS colour chart. The Natural Color System is a universal system used for standardised colour communication, based on an intuitive coding system designed for human vision. This reference system allows us to communicate colours universally in different fields of application. This representation has also allowed us to translate these colour readings into values using the CIE XYZ L.a.b system, taking into account the logarithmic response of the eye, but also the specific characteristics of coloured surfaces with their luminance index.

3.3 Step 2: Creation

The first phase consisted of a study of the existing light, the environment, the chromatic and architectural identity of the site.

Each environment has a unique identity, of which colour and light are part. The mission of the CLM research engineer must necessarily include a diagnosis of the existing environment. This stage defines the way in which we will approach the existing environment and certain elements in relation to the project, but also in relation to the wishes of the developer in terms of the expected aesthetic and functional ambitions. In this phase, we have taken into account the so-called "permanent" and "cyclical" colours. The "permanent" colours are the basis of any chromatic study. They constitute the stable elements of the place, having a durable character, such as the building materials. They are opposed to "cyclical" colours, which are unstable and subject to innumerable temporal, meteorological and light variations, such as the colour of patinas, plants, the sky (etc.).
The second phase consisted of recommending atmospheres adapted to the place, using chromatic ranges, materials and lighting systems that favour the safety and visual comfort of all inhabitants. This method consisted of experimentally constructing chromatic ranges by means of the view, proceeding by variation and multiplication of optical combinations until a visual impression was obtained that conformed to the aesthetic expectations of the project. To design these colour schemes, we used the NCS colours previously surveyed on the site, which we then matched with the paint and material manufacturers' colour charts used for the project. Thus, a visual atmosphere was designed around the spirit of the place, the chosen shades are sublimated by the contribution of contrast around several soft and assertive tones inspired by nature and harmonizing perfectly with the vegetation present on the site. These prescriptions have led to the creation of three chromatic palettes specific to each building in the project, (see figure 2).

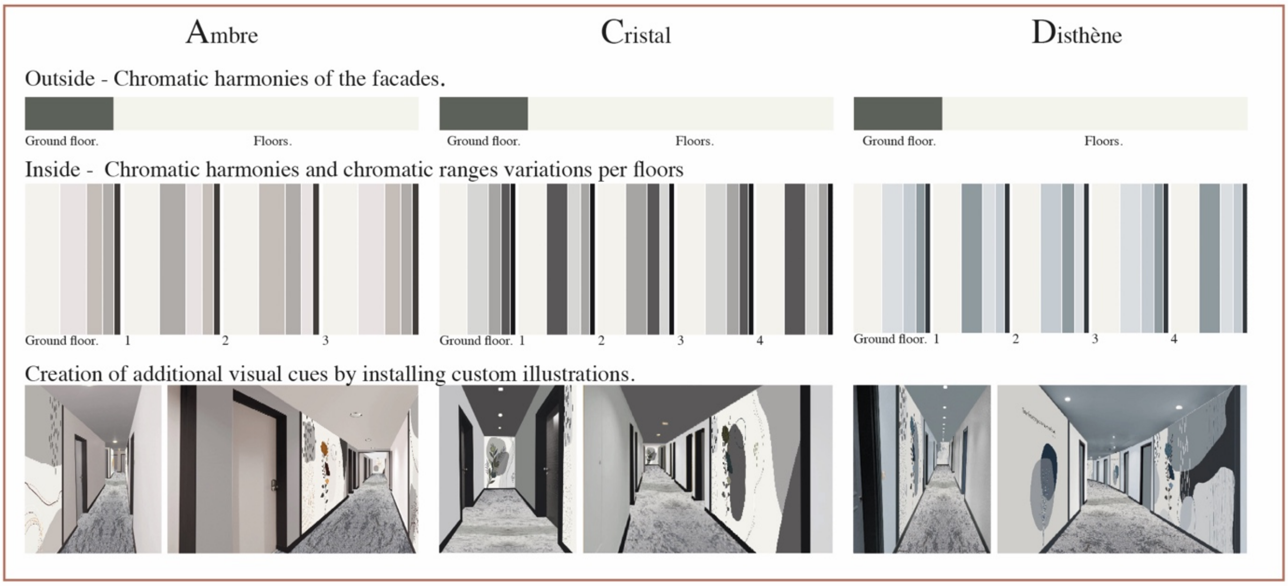

Fig. 2 - Chromatic environment creation.

Inside, the chromatic combinations are composed of five shades, but established on a dominant trichromy (Déribéré, 2014), varying at each level, thus avoiding any visual disturbances caused by a discordant polychromy, and relieving the space of a certain visual monotony recurrent in this type of place. Particular attention was paid to chromatic contrast and luminance values, as contrast sensitivity generally decreases with age and can be even more disturbed when visual pathology is added. For example, a contrast of 70% has been maintained between the various important media so that they can be perceived by a visually impaired person, whose sensitivity to contrast is still operative.
Here, light colours are used for large surfaces and dark colours for small surfaces or accessories in order to allow better discrimination of the elements. The creation of these differentiated harmonies has therefore allowed us to design circulation spaces with chromatic variations for each level, favouring intuitive orientation as well as an efficient and comfortable reading of the chain of

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movement for all inhabitants. This colour scheme was accompanied by numerous contrasting visual markers, designed for the occasion. The 77 illustrations installed in the residence not only serve as landmarks, but also have the advantage of dynamising and reducing the perception of large landings and long corridors which can be perceived as anxiety-provoking.
Thus, this evidence-based approach to colour and contrast integrated into the design of the environment improves visual awareness of the environment. This approach, which is aimed at older people, visually impaired people and people with dementia, is in line with inclusive design guidelines and supports orientation and wayfinding, as well as the safe performance of daily activities.
Finally, these harmonies were also accompanied by a lighting design. This was studied so that the quantity and quality of light would meet the needs of all inhabitants, as at 55 years of age the amount of light required is 300% higher than at 25 years of age, for an equivalent level of visual performance, (Association française de l'éclairage, 2020). For this reason, we recommended an average of 300 lux at floor level, homogeneous throughout the buildings, using direct and indirect LED lighting with a colour temperature of 3000 Kelvin. Finally, the choice of materials was studied in order to recommend finishes ranging from matte to satin in the entrance halls according to their natural light contribution in order to adapt to each exposure and thus not generate glare or darkness.
Finally, the third phase was the creation of a technical execution file for the project management. This file is based on and complements the documents provided by the project architect and includes normative descriptions as well as graphic documents such as colouring diagrams on plans, lighting system layout diagrams, cross-sections, a details and signage booklet, as well as a material library to ensure the proper implementation and monitoring of the project.

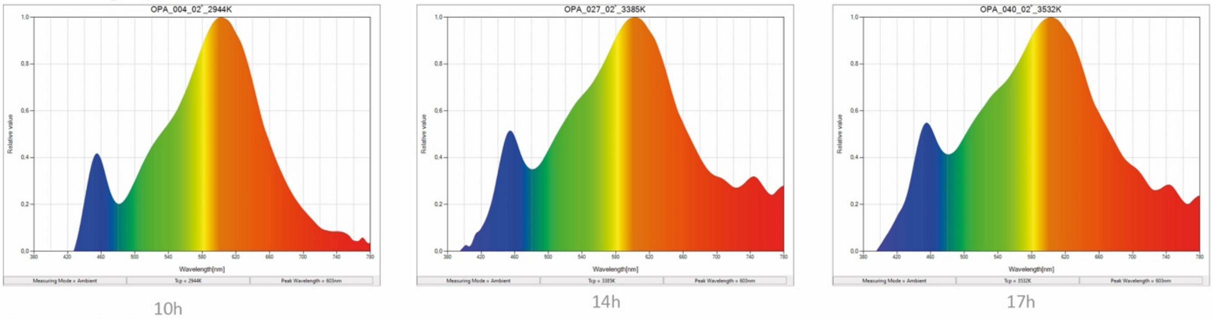
3.4. Step 3: Feedback

Finally, following the completion of the works and the installation of the inhabitants, we repeated a series of measurements inside the various common areas. These measurements provided additional information on the relevance and effectiveness of the recommendations made prior to the project. This last observation phase consisted of characterising the light and colour present in the buildings. To do this, we carried out several series of measurements along the movement chain.
First of all, we repeated a referencing of the environment inside the common areas with the help of photographs and chromatic counter-types. These chromatic collections were used to draw up a cartography. Establishing a chromatic representation of a place through a cartography allowed us to produce a qualitative and quantitative restitution of the colours collected in situ, in order to draw up a visual synthesis and to validate the efficiency of the contrasts.
Secondly, we carried out a series of measurements to characterise the lighting environment of the site. The evaluation was carried out at three different times of the day (morning at 10:00, early afternoon at 14:00, late afternoon at 17:30) to measure the light amplitude. In addition, in order to analyse the light distribution of the area, the area was divided into several zones of the site (strategic point of the movement chain).
This series of measurements was carried out using a CRI Luxmeter-Chromameter (Minolta CL-70 F), allowing us to collect all the values composing the light such as its colour temperature; its illuminance; its light spectrum and its colour rendering index, (see figure 3).

Example of readings to characterise the interior light

«Ambre» building, ground floor :

Evolution of light spectra :



Measures taken :

Hours	INTERIOR LIGHTING SURVEYS		OUTDOOR LIGHT SURVEYS	
	Illuminance (lux)	TPC (Kelvin)	Illuminance (lux)	TPC (Kelvin)
10h	303 lux	2838 K	8090 lux	6155 K
14h	473 lux	2898 K	43300 lux	5864 k
17h	547 lux	2780 K	13600 lux	6500 K

Fig. 3 - Collection of values composing the light of common spaces.

Secondly, we used a video luminance meter, which allowed us to collect the values that make up the light comfort of these spaces, such as luminance, unified glare ratio (UGR), daylight glare index (DGI) and visual comfort probability. In order to analyse the light distribution of the different spaces that make up the residence, the surveys were divided into several zones, consisting of strategic points in the movement chain specifically lit with natural or artificial light. We then chose three periods of the day to carry out the measurements.

This distribution in time makes it possible to analyse the evolution of the amount of light during the day, mainly in the halls and the sharing lounge (common space intended for the creation of sharing workshops between the inhabitants). Also, in order to compare the values between artificial and natural light, we also carried out measurements of the external light, simultaneously with the internal light. These photometric collections were used to draw up a measurement table showing the quantities of light and colour temperatures perceived during the day in different areas of the residence.

Finally, we plotted these data on the Kruithof curve in order to deduce whether the visual environments were considered comfortable or not for the observers, (see figure 4).

Example of readings to characterise the interior light.

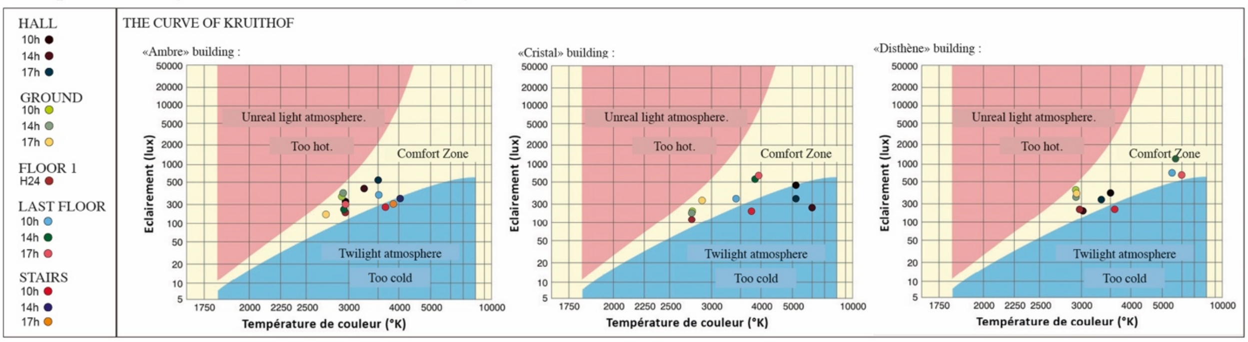


Fig. 4 - Visual comfort control with the Kruithof curve.

Synthesising this information allowed us to produce a qualitative and quantitative restitution of the light present in situ, in order to draw up a visual synthesis and to validate the efficiency and possible nuisances during the day.

Finally, a survey was carried out among the inhabitants in May 2022. The survey was administered by paper questionnaire; residents were asked to share their age, physical condition and the name of their building. The questionnaire consisted firstly of measuring the general satisfaction with the care given to the (interior) environment of the residence and secondly of describing in detail their long-term visual impression of the common spaces. They then assessed their comfort over the course of the month for three specific periods of the day: in the morning, from 8:00 am to 12:00 pm; at noon, from 12:00 pm to 2:00 pm; and in the afternoon, from 2:00 pm to 6:00 pm in different spaces of their residence. For each of these intervals, residents were asked to rate their visual comfort in one of four categories: imperceptible, noticeable, disturbing or intolerable.
Thus, the visual comfort and general appreciation ratings of the residents were compared to the measurements carried out in situ in order to correlate the metric data collected with the visual atmosphere felt.

4. Result
The different phases of surveys and analyses contributed to demonstrate in a quantitative and normative way how the place could be perceived by the inhabitants (INSEE, 2017).
The interpretation of the results obtained at the time of delivery enabled us to validate the efficiency of the recommendations established thanks to the analysis protocol carried out before the project, beyond the consideration of the standards in force, this one calling upon an experimental construction method (Pfeiffer, 1966), taking into account several factors intrinsic to the project and which will be reiterated on the projects to come:
- The analysis of the characterisation of colour and light on the site.
- The spirit and visual coherence of the project location.
- An efficient chain of movement.
- The comfort of use and appreciation of the spaces for all inhabitants.

We can conclude that this research-creation protocol and the expertise carried out around the chromatic and luminous characterisation within the circulation spaces was validated by the feedback established in the last phase. Indeed, the measurements taken in situ correlated with the feelings of the inhabitants validated the hypothesis that this approach generates more visual reference points and comfort of use for all the inhabitants. Moreover, these results were compared to other data collected on a sample of the developer's previous real estate projects that did not benefit from this creation protocol and did not have such good results; this confirmed the fact that this new design approach is now a health and social necessity.

5. Discussion
The issue of lighting and colour in collective housing is quite complex, as designers' preferences vary greatly according to both objective and quantifiable conditions (economy, standardisation of practices, specific needs related to disabled people, etc.) and socio-cultural and subjective conditions (preference for a particular colour scheme, type of luminaire, type of covering, etc.).
As a result, and in the absence of standards directly related to these semi-private spaces, architects tend to use very neutral or even monotonous colours and materials, and struggle to install sufficiently efficient, comfortable and aesthetic lighting in common spaces. With this study, we are beginning to awaken designers to the challenges of colour and light. Because together, beyond their simple aesthetic contribution, they make circulation safe and efficient while allowing the inhabitants to plunge into singular universes where the atmosphere becomes a factor of well-being and cohesion.

6. Conclusion
In the coming years, a larger comparative study will complete the research-creation protocol studied in this article. This comparative study will take into account the values obtained in a large sample of old residences and those that are being built from this protocol, and will be completed by an

interview with the inhabitants asking them about their perception of the place and based on a scale of sensations. This study will allow the property developer to ensure the efficiency of its approaches and to continue to design in a systematic and sustainable way visual environments better adapted to human physiological needs by proving the validity of qualitative approaches in terms of the design of light and colour within its property programmes.

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I am grateful to the LAPLACE Laboratory of the Paul Sabatier University in Toulouse, France, which made the experiment possible by providing tools. I also thank the company SOBRIM for allowing me to carry out this study and for their interest in the results. Finally, I thank them for their willingness to enhance and develop their academic research within their future real estate programmes through the HARANAM approach.

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Eidomatic experimentations on alteration of spatial perception by using colours

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Abstract

Ancient Greeks already had expertise in the use of colour effects to alter perception of architectural volumes and spaces. Awareness of these techniques evolved throughout history thanks to the Theory of Colours, based primarily on phenomenological observations. The advent of Gestalttheorie and Abstractionism then triggered a reexamination of these issues from a much more conceptual standpoint. Recent studies on chromatic illusions and effects, carried out by contemporary science, do not just allow us to address the subject of perception of Architecture in a new way: they also enable us to reconstruct certain types of stimuli, hitherto only meaningfully obtained with two-dimensional graphic models, through digital modelling of three-dimensional architectural spaces. Thus, in this paper we analyse the phenomena of chromostereopsis, apparent contraction of edge angles, chromatic induction, and neon colour spreading. We then propose some experimental three-dimensional virtual models, derived from the two-dimensional models of graphic stimuli pertaining to the aforementioned optical effects.

Keywords: representation of Architecture, visual perception, colour perception, optical illusions, Eidomatics.

1. Introduction

Historians of Architecture such as B. Fletcher pointed out that certain techniques for manipulating volumetric and spatial perception of buildings and environment were already being used by ancient Greeks, in order to make the proportions of colonnades stand out against temple cells (Fletcher, 1996). The Theory of Colours, developed over the course of history thanks to fundamental contributions such as those of J. W. von Goethe and J. Itten, extended the investigation of these phenomena not only to all the arts, but also to everyday reality (Goethe and Eastlake, 1840; Marotta and Vitali, 2017). The rise of Gestalttheorie and Abstractionism then prompted a search for a new definition of the influence of colour on perception of space and movement (Albers, 1963; Arnheim, 1969). Several contemporary handbooks such as the famous 'Bauentwurfslehre' by E. Neufert revisit and convey these notions on visual perception of architectural space (Neufert, 1984). Results achieved in the photometric, medical, psychiatric, and psychological fields allow us to analyse these phenomena further, even from an ophthalmological and neurological perspective. Based on these scientific observations, we are going to review four chromatic effects which have an impact on volumetric and spatial perception at architectural scale: chromostereopsis, apparent contraction of edge angles, chromatic induction, and neon colour spreading. After reviewing some types of stimuli, related to these four phenomena and generated with two-dimensional graphical models, we are going to illustrate digital modelling of experimental three-dimensional constructions and installations by which we can induce the same effects on observers.

2. Literature review

2.1. Literature review about chromostereopsis - Chromostereopsis is a historically well-documented phenomenon of binocular stereopsis. It depends on binocular disparity due to difference in colour, but can also be experienced by colour-blind individuals. When it occurs, colours on a single surface are perceived as lying on different planes of depth. Although he did not recognise the binocular nature of chromostereopsis, J. W. von Goethe was probably the first to propose the notion of expanding (or advancing) 'warm hues' versus shrinking (or receding) 'cold hues' (Goethe and Eastlake, 1840; Kitaoka, 2015; Vos, 2008). However, this still widely used interpretation does not take into account the considerable influence of environment on the evolution of hereditary concepts related to colour distinction (Arnheim, 1969; Casale, 2018). For example, in 18th century Germany, heat was mainly associated with the yellow, orange, and red colours of bonfire flames but, today, modern star classifications contradict this synaesthetic suggestion, attributing the highest surface temperatures to stars that emit blue light (Montmerle et Ekström, 2011). Although the causes of chromostereopsis have not been fully explained yet, its phenomenology is well defined. When a stimulus with blue and red elements on a white background is presented (Fig. 1a), most humans perceive the blue elements in front of the red ones. When the background is black (Fig. 1b), these individuals perceive the red elements in front of the blue ones, with a stronger impression. However, there is a minority of people for whom the opposite applies. These persons perceive red elements in front of blue ones on a white background and vice versa on a black background. Finally, there is a third group of humans who do not experience chromostereopsis under any circumstances. It is currently believed that the phenomenon is due on the one hand to the interaction between optical properties of coloured rays and the visual apparatus and, on the other hand, to further neural processing. Despite some weaknesses in his justification of this phenomenon, E. W. von Brücke conceived one of the most elegant models by contemplating transverse chromatic aberration (Fig. 1c). According to Brücke's proposal, since refractive index varies according to the frequency of incident wave, red light is projected onto a more temporal part of the retina than does blue light: this would cause the apparent difference in perceived depth between one colour and the other (Kitaoka, 2015; Vos, 2008).

2.2. Literature review about apparent contraction of edge angles - Humans perceive their natural environment as delimited by edges and have a tendency to underestimate the angles at the borders of a surface. This also applies in space, even when surfaces belong to solids. In such cases, a right angle may appear slightly acute. Revisiting concepts anticipated by Leonardo da Vinci, H. Pierce, H. von Helmholtz and then B. Moulden with J. Renshaw attributed the causes of this phenomenon to irradiation, justifying the starker impression of corners in white squares by the greater magnitude of their diffusive effects, to the disfavour of corners in black squares (Kitaoka, 1998; Wade, 1996). A. Kitaoka noted, however, that the opposite is also true and so proposed an alternative explanation: the apparent contraction is an orientation illusion specific to corner edges, and the edge orientations perceived by the observer tend to favour angle contraction. A local polar symmetry between two areas in strong brightness contrast cancels this effect if their surfaces are equally distributed, but strengthens it if one area is larger than the other. Should this polar symmetry be repeated in linear patterns, cut by a sufficiently thin central segment, the phenomenon reaches its maximum effectiveness. In Kitaoka's 'checkered illusion' (Fig. 1d), a slight inclination of the segment passing between the two horizontal lines of squares is perceived but, in reality, this central segment is also perfectly horizontal. At polar symmetry centres between pairs of black squares, the sum of the effects of counterclockwise (+) and clockwise (-) rotations is null, while those applied to the ends of the horizontal segments between squares are both counterclockwise and, therefore, concordant (Fig. 1e). These linear patterns can in turn be arranged in an array: in Kitaoka's 'illusion of flying squares' (Fig. 1f) the corner contraction effect apparently distorts the pattern, giving an impression of three-dimensionality (Kitaoka, 1998).

2.3. Literature review about chromatic induction - Though the first studies about colour contrast can be traced back to at least Aristotle (Wade, 1996), contribution of assimilation and contrast to colour induction has only recently begun to be examined. When an area is enclosed by a coloured surround and both are partially masked by a grating of another colour, this area appears to turn towards a mixture of the colouration of the grating (assimilation) and of the opposite of the colour in the surround (contrast). In the 'chromatic dungeon illusion' (Fig. 1g), colour induction causes the left circle to be perceived as magenta and the right circle as orange but, in reality, they are both hot pink. Decomposing this illusion, we find that contribution provided by colour contrast between circles and backgrounds is relatively modest (Fig. 1h), while contribution provided by assimilation between circles and gratings is conspicuous to some degree (Fig. 1i). Some works by G. A. Sarcone exploit assimilation and contrast to achieve particular visual effects: in 'Ovulatio 1', also known as 'No Pink' (Fig. 1j), the perception of a pink halo is induced by superimposing a blue and a cyan pattern on a white background; in 'Ovulatio 3', also known as 'No Blue' (Fig. 1k), the impression of a dark blue halo is likewise induced by superimposing a red, a grey, and a yellow pattern on a white background (Kitaoka, 2010; Sarcone, 2007a; Sarcone 2007b).

2.4. Literature review about neon colour spreading - As pointed out by D. Varin in 1971, neon colour spreading occurs in the perceptual system of the observer when parts of a black pattern on a white background are replaced with coloured ones, provided that this colour has an average brightness compared to those of the pattern and the background. Thus, the illusion of a semi-transparent, geometrically regular area overlaid on both pattern and background is generated (Fig. 1l). The phenomenon can also work in reverse, with a white pattern on a black background, but the result will be weakened. The effect can also occur with just grayscale stimuli, taking the name of neon brightness spreading (Fig. 1m and Fig. 1n). As remarked by Gestalttheorie, simplicity, order, symmetry, and regularity are fundamental tools of human thought and are reflected in perception: the demands of our perceptual apparatus for systematicity and recognisability influence perception to such an extent that colour-based integration is induced (Bressan, Mingolla, Spillmann and Watanabe, 1997; Casale, 2018; Kitaoka, 2010). Interpretation of these semi-transparent shapes can be barely constrained, leaving the observer in doubt about whether he or she is looking at circles or diamonds (Fig. 1o), but it can also be very much forced by pattern design (Fig. 1p).

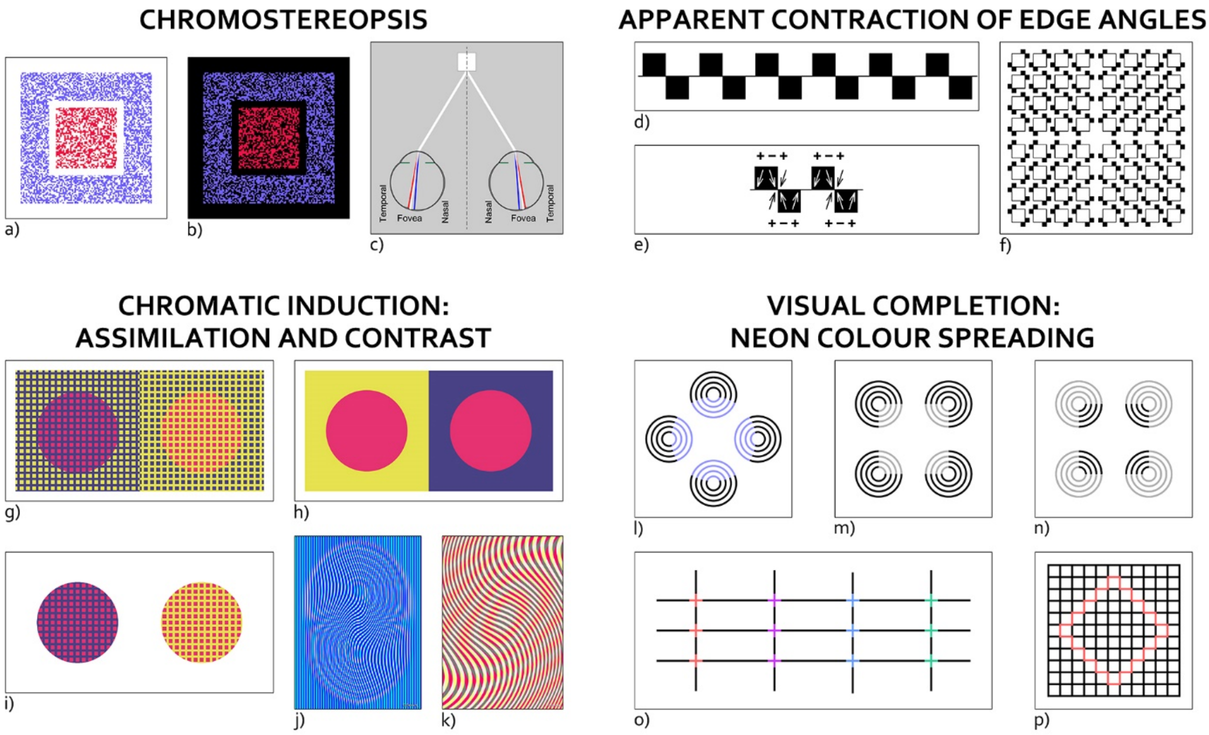

Fig. 1 - Two-dimensional stimuli of the chromatic effects selected for this study: a), b), c) chromostereopsis; d), e), f) apparent contraction of edge angles; g), h), i), j), k) chromatic induction; l), m), n), o), p) neon colour spreading. 'Checkered illusion' and 'illusion of flying squares' reproduced with permission of Akiyoshi Kitaoka. 'Ovulatio 1', also known as 'No Pink' © 2007 Gianni A. Sarcone/Archimedes Lab, Genoa, Italy. 'Ovulatio 3', also known as 'No Blue' © 2007 Gianni A. Sarcone/Archimedes Lab, Genoa, Italy.

3. Methodology

During space perception, the three-dimensional character of reality is lost at retinal level, yet it is reconstructed at the level of vision, assuming the latter as a global psychic experience. Whereas tracing the projection of an object onto the retina is a univocal operation, the reconstruction of an object from a projection is an undetermined process with more than one valid result: several objects in many positions may determine the same projection (Bonanno, 1986; Casale, 2018). Taking

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advantage of such manifoldness, we have interpreted some stimuli discussed earlier as orthogonal views of three-dimensional installations. We then digitally modelled these installations and a space designed to contain them, in order to render some perspectives that would produce similar effects.

4. Experiments and results

4.1. Experiments on chromostereopsis and respective results - The concentric wall construction and the different proportions of columns deprive the central observer of many 'depth hints' (shrinking, cast shadows, etc.), namely elements that allow attribution of spatial value and locationing of objects (Bonanno, 1986). Chromostereopsis can thus alter placement of individual columns, so that they may appear illusorily closer or further to the observer than the others (Fig. 2).

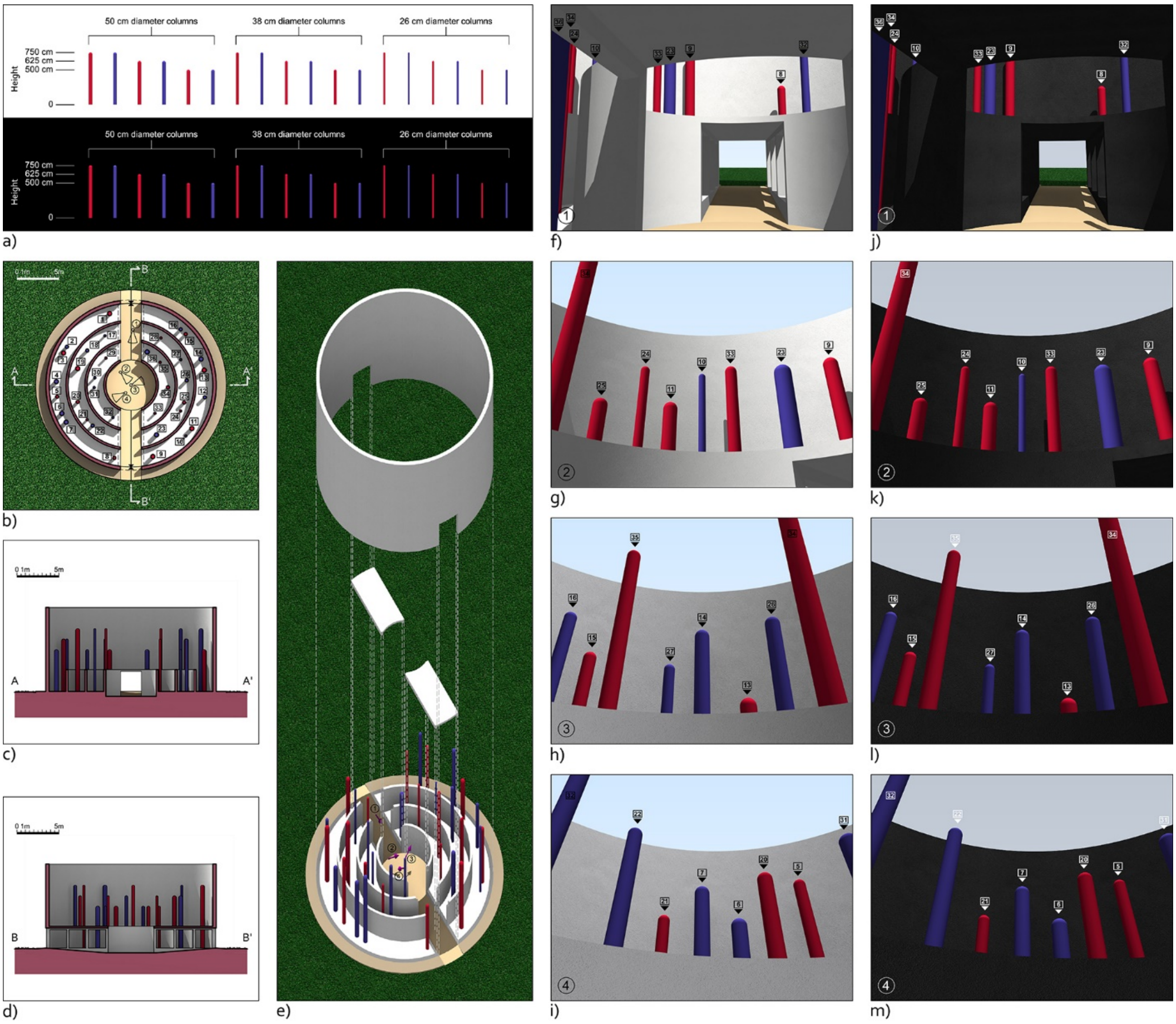

Fig. 2 - Virtual three-dimensional model for studying the effects of chromostereopsis: a) comparison of the types of columns used; b) plan of the construction, with identification codes of columns and perspective viewpoints; c) vertical section A-A'; d) vertical section B-B'; e) cutaway render of the construction in military projection, with identification codes of perspective viewpoints; f), g), h), i) perspective views (with identification codes) of the construction with white walls and natural lighting; j), k), l), m) perspective views (with identification codes) of the construction with black walls and natural lighting.

4.2. Experiments on apparent contraction of edge angles and respective results - A. Kitaoka's 'illusion of flying squares' induces in the observer the sensation of an array of squares that loses its regularity in the centre, becoming rotund (Kitaoka, 1998). The regularity of the pattern design easily permits a three-dimensional transposition: cubes correspond to squares, while edges and frames correspond to lines (Fig. 3a). If the installation is exposed to congenial natural lighting (Fig. 3i, Fig. 3m) or to dedicated artificial lighting (Fig. 3g, Fig. 3h, Fig. 3j, Fig. 3k, Fig. 3l, Fig. 3n), when observed from a sufficiently frontal perspective, the central bulging effect is reinforced by vanishing lines and shading. When observed from a foreshortened view, the set-up loses the effect of apparent central roundedness, but the outer borders of the array appear to rotate more, illusorily misaligning outer edges of the four groups of cubes. The phenomenon is most effective when using black and white, but can also be experienced significantly with a colour combination that provides sufficient contrast of hue and brightness.

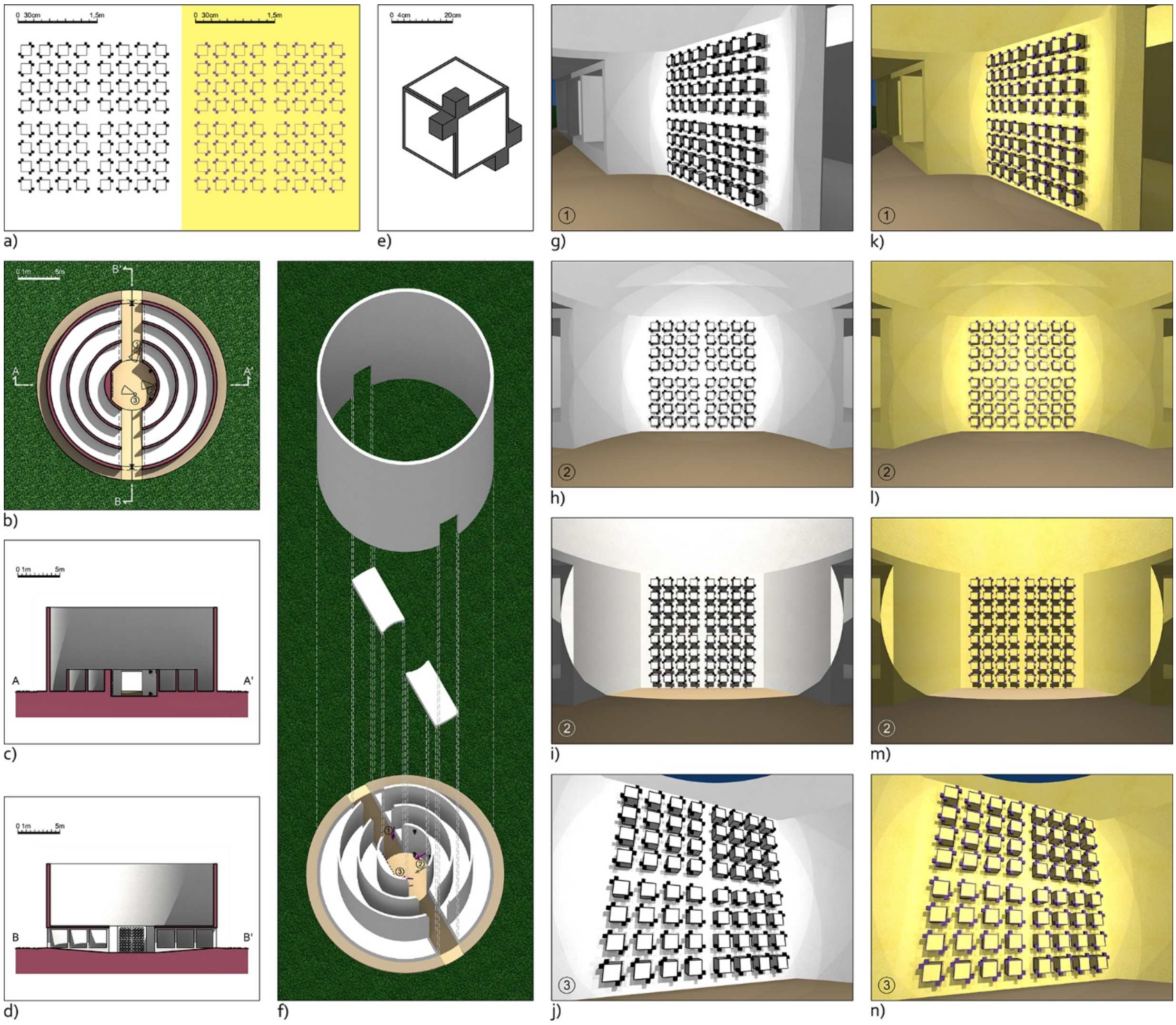

Fig. 3 - Virtual three-dimensional model for studying the effects of apparent contraction of edge angles: a) front views in orthogonal projection of the installations derived from the 'illusion of flying squares' in black and white (left) and in yellow and purple (right); b) plan of the construction, with identification codes of perspective viewpoints; c) vertical section A-A'; d) vertical section B-B'; e) detail of a single element of the installation, in isometric axonometry; f) cutaway render of the construction in military projection, with identification codes of perspective viewpoints; g), h), i), j) perspective views of the installation in black and white; k), l), m), n) perspective views of the installation in purple and yellow. 'Illusion of flying squares' reproduced and modified with permission of Akiyoshi Kitaoka.

4.3. Experiments on chromatic induction and respective results - We have transposed the works 'Ovulatio 1' and 'Ovulatio 3' by G. A. Sarcone into three-dimensional space, obtaining the superimposition of semi-transparent, non-planar coloured surfaces anchored to a rectangular frame (Sarcone, 2007a; Sarcone 2007b). In both cases, we interpreted the patterns of the originals as orthogonal projection views of a series of strip surfaces, in order to exploit the white walls of the virtual construction as an interstitial background (Fig. 4a, Fig. 4g). In the case of 'Ovulatio 1', the halo induced at the interstices appears lilac instead of pink (Fig. 4c, Fig. 4d, Fig. 4e, Fig. 4f): this is attributable to an increased contribution by assimilation, due to the narrower spacing between blue and cyan strips. As for 'Ovulatio 3', we thought of simplifying the three-dimensional transposition by superimposing only red and yellow surfaces: the exclusion of any grey surfaces is justified by the fact that they would have been redundant, given the strong presence of background shading. As can be seen from perspective views, it is mainly interstitial halos corresponding to the white wall shaded parts in the background to turn blue (Fig. 4i, Fig. 4j, Fig. 4k, Fig. 4l).

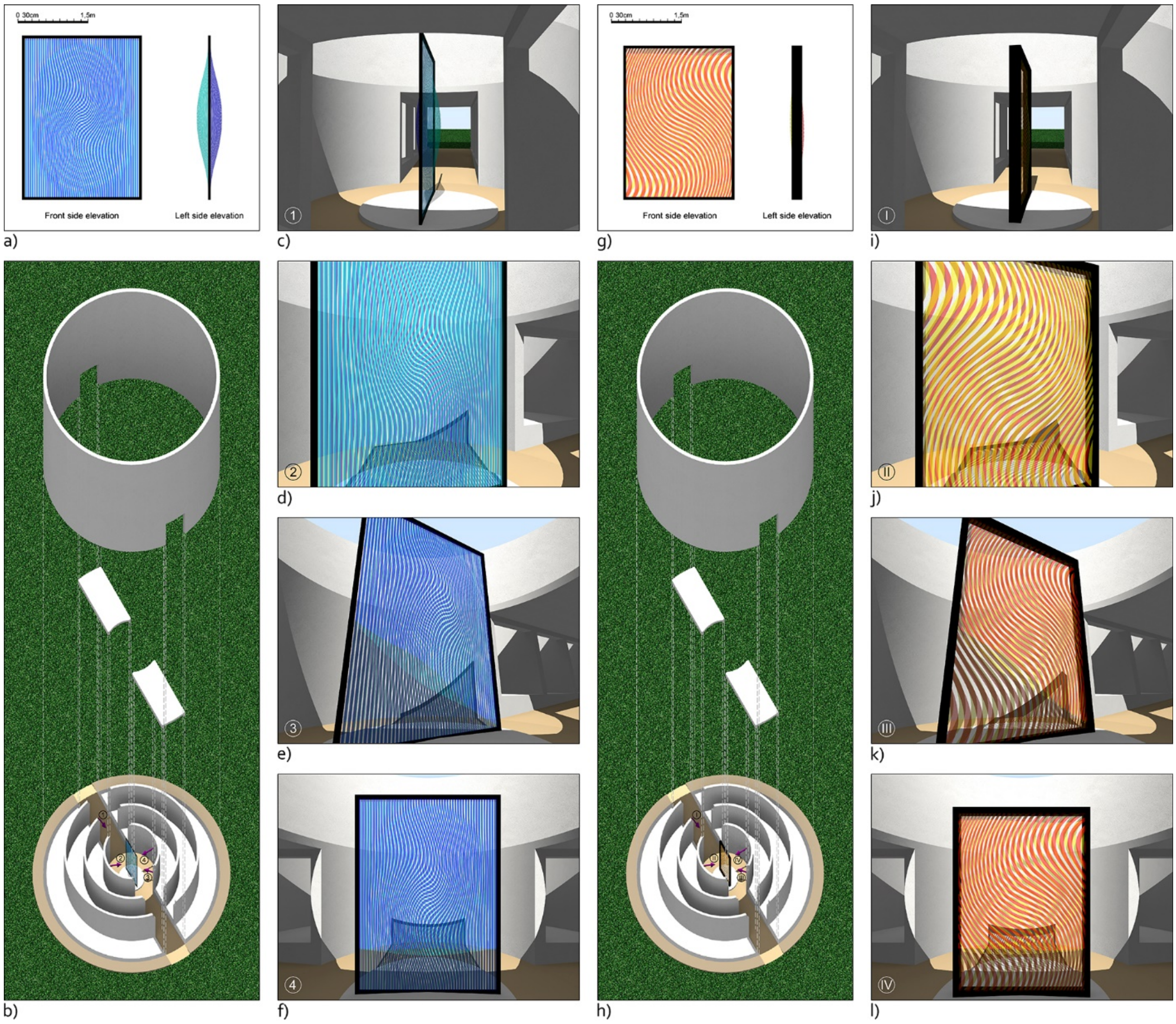

Fig. 4 - Virtual three-dimensional model for studying the effects of chromatic induction: a) front and left elevations of the three-dimensional transposition of 'Ovulatio 1'; b) cutaway render of the installation derived from 'Ovulatio 1' in military projection, with identification codes of perspective viewpoints; c), d), e), f) perspective views of the installation derived from 'Ovulatio 1' with natural lighting; g) front and left elevations of the three-dimensional transposition of 'Ovulatio 1'; h) cutaway render of the installation derived from 'Ovulatio 3' in military projection, with identification codes of perspective viewpoints; i), j), k), l) perspective views of the installation derived from 'Ovulatio 3' with natural lighting. 'Ovulatio 1', also known as 'No Pink' © 2007 Gianni A. Sarcone/Archimedes Lab, Genoa, Italy. 'Ovulatio 3', also known as 'No Blue' © 2007 Gianni A. Sarcone/Archimedes Lab, Genoa, Italy.

4.4 Experiments on neon colour spreading and respective results - We have adopted a black grating and a black cylindrical frame instead of the two-dimensional patterns seen in literature review. However, we chose much simpler designs, as more complex geometric shapes would only have produced appreciable effects from sufficiently frontal views. Our interest was instead in verifying the phenomenon subsistence from very different points of view (a complex task in the case of the cylindrical frame) (Fig. 5). We used aqua-green opaque markings for the grating (Fig. 5c, Fig. 5d, Fig. 5e) and yellow opaque markings for the cylindrical frame (Fig. 5i, Fig. 5j, Fig. 5k), as well as translucent inserts of the same colours (Fig. 5f, Fig. 5l). Paradoxically, perception of semi-transparent superimposed segments and curves is stronger in renders with opaque markings while, in renders with translucent inserts, assimilation with background prevails, making it seem as if the grating and the frame are just missing pieces. This is due to the fact that transparent materials are much more complex to represent with three-dimensional models than with two-dimensional ones, as many more factors are involved than simple colour overlapping. As a result, opaque markings assume more equidistant brightness values between the black of the bars and the chiaroscuro of the white background wall than translucent inserts, better facilitating illusion in the respective cases.

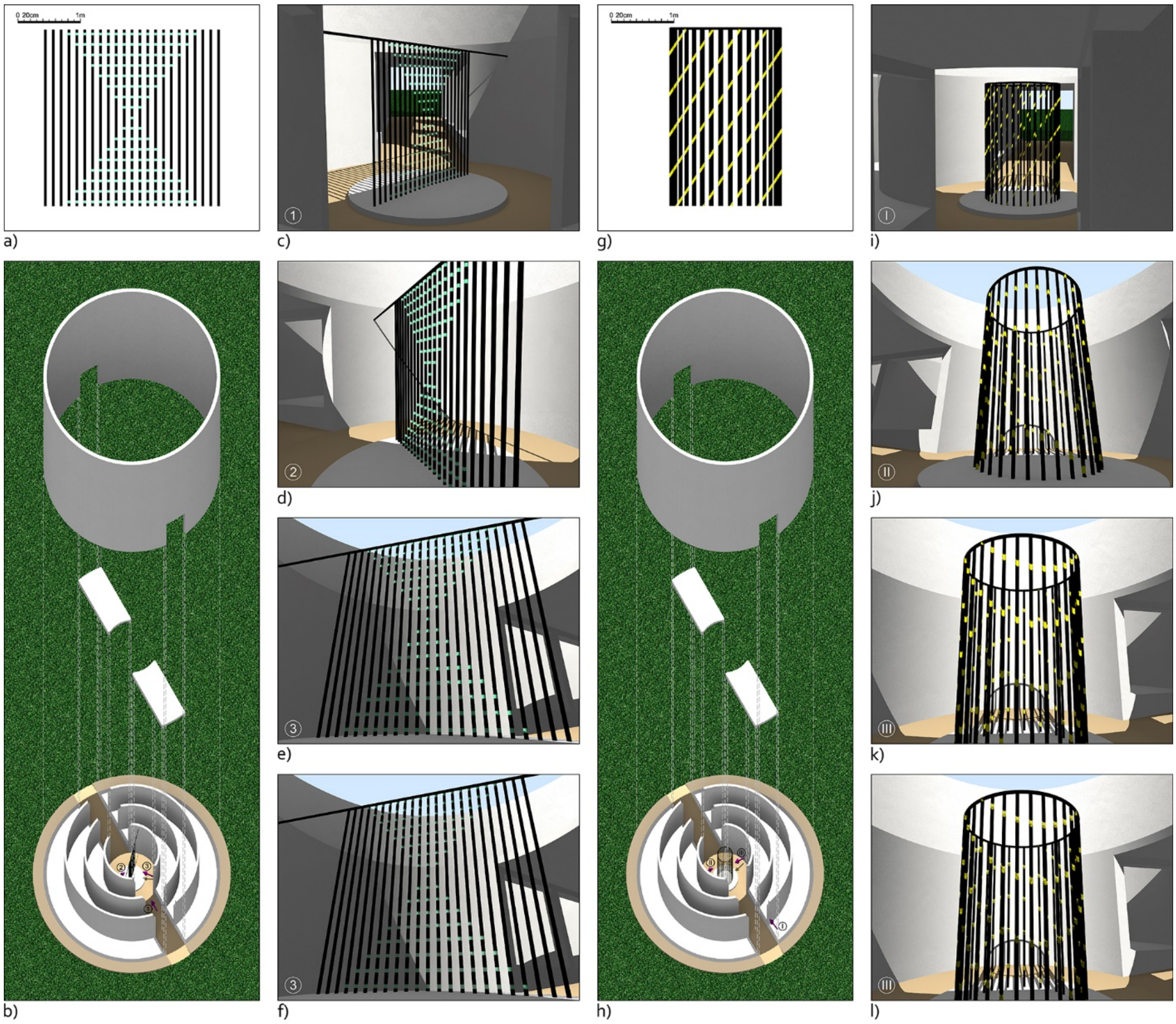

Fig. 5 - Virtual three-dimensional model for studying the effects of neon colour spreading: a) front elevation of the grating with aqua-green markings arranged in horizontal stripes; b) cutaway render of the construction and the grating in military projection, with identification codes of perspective viewpoints; c), d), e) perspective views of the grating with opaque markings; f) perspective view of the grating with translucent inserts; g) front elevation of the cylindrical frame with yellow opaque markings arranged in oblique (elliptical) sections; h) cutaway render of the construction and the cylindrical frame in military projection, with identification codes of perspective viewpoints; i), j), k) perspective views of the cylindrical frame with opaque markings; l) perspective view of the cylindrical frame with translucent inserts.

5. Conclusions

We have considered two-dimensional stimuli for four perceptual phenomena (chromostereopsis, apparent contraction of edge angles, chromatic induction, and neon colour spreading) as orthogonal views of three-dimensional models. Then, we digitally reconstructed the latter. From these eidomatic models we finally generated perspective renders, capable of inducing the same optical effects in the observer. These results reaffirm the efficacy of a number of chromatic techniques applied to Architecture since antiquity and pose new considerations, to be developed and refined, concerning perception of built spaces and environment. A further step in this research could be to study these phenomena in relation to a dynamic observation of three-dimensional eidomatic models, therefore considering a moving user. Another topic to be explored could be the consequences of these chromatic effects on certain functional aspects of Architecture, such as step signalling for stairs or wayfinding in facilities for collective use.

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Felting wool dyed with natural dyes

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Abstract

Starting from the basic idea of ecologically safe production, the possibilities of using natural materials to create aesthetic and useful handmade eco-products are explored. Thus, natural dyes were the logical choice for dyeing natural protein fiber - wool. The wool of Croatian Pramenka sheep from the island of Cres was used, and plants that thrive in Croatia served as the source of natural dyes. The problem of wool as unwanted waste, which exists today on our islands, was an even greater motivation to use the wool from Cres. Considering its alleged poor quality, i.e. a fineness that does not meet the requirements of the textile industry (because it is coarse and full of dirt), the wool from Cres is not very interesting, so after shearing it is scattered on the pastures of the islands. This is very harmful to the environment, because the wool does not completely decompose in nature and hinders the growth of vegetation in the place where it is scattered. Plants characteristic of traditional Croatian handicrafts were used for dyeing: walnut shells (*Juglans regia* L.), oak bark (*Quercus robur* L.), yarrow leaves and flowers (*Achilea millefolium* L.), nettle leaves (*Urtica dioica* L.), chamomile flowers (*Chamaemelum recutica* L.), marigold flowers (*Calendula officinalis* L.) and flowers and leaves of St. John's wort (Hypercum perforatum L.). Pre-treatment of wool with metal salts was carried out at 100 °C for 60 minutes with the addition of 2% metal salts (mordants) and 5 g/l tartaric acid (pH 4.5). The following metal salts were used as mordants: copper(II) sulphate pentahydrate p.a. (Cu ion), potassium aluminium sulphate dodecahydrate p.a. (Al ion), and iron(II) sulphate heptahydrate p.a. (Fe ion). The wool, which took on a whole range of pleasant earth tones as a result of dyeing, was transformed into a work of art by the felting technique. The felting was performed by wet and dry felting. The motifs of the individual felt works tell the magical story of the island of Cres. The images created by felting waste wool dyed with vegetable dyes are an example of good practise of the circular economy.

Keywords: natural dyes, wool, felt, circular economy

Introduction

Wool, once a very popular and useful resource of nature, is on the top of the list of undesirable raw materials on the Croatian islands. On the island of Cres, as in other areas, wool became a great burden for the entire community. The sheep, which used to be much more numerous on the island, nowdays produce about 20 to 25 tons of wool per year. In the past, this important local source of textile raw material was used for clothing and other purposes, and the wool was purchased and sent to domestic and foreign textile mills for processing. In the last fifty years, due to the insufficient fineness of Croatian wool for the textile industry and the high cost of transportation, the wool has become an unwanted waste. The island shepherds are mostly elderly, their sheep and pastures are far from the main road of the island, so collecting the wool and transporting it to the place of purchase is a big problem for them, and the price obtained for the purchase is not motivating either. The wool, after shearing the sheep, is usually left in nature, in ditches, pits and meadows, where the wool is not only esthetic, but also a great environmental impact (Fig. 1). Nothing grows in the places where it is left, so grazing areas are reduced. In addition, the wool stinks and becomes a suitable place for bacteria to develop. It should not be stored in the municipal landfill, as it favors the development of rodents. In the construction industry there was an idea to use wool for the production of insulating material, but the quantities collected annually on the island are not enough to start such production (Glogar *et. al.* 2020).

Fig. 1 - Wild wool dumps

From a design, environmental, and economic perspective, wool waste can be used for high-value wool products, such as felt. In addition to the selection of fibers, the dyes used in the textile industry have a significant impact on the health of the user and the environment. Today, synthetic dyes are mainly used in the textile industry. However, as consumer awareness of the harmfulness of the chemicals used grows, there is renewed interest in natural dyes (Samanta *et. al.* 2009). They are biodegradable and offer a wide range of beautiful harmonious shades, (Botteri *et. al.* 2022; Hofenk de Graaff, 2004).

Experimental part

1. Dyeing wool with natural plant dyes

Native wool of sheep from the island of Cres of the Pramenka breed with a fiber fineness of 60-70 μm was used. Plants characteristic for traditional Croatian handicrafts are used for dyeing: walnut shell (*Juglans regia* L.), oak bark (*Quercus robur* L.), leaves and flowers of yarrow (*Achilea millefolium* L.), nettle leaves (*Urtica dioica* L.), chamomile flowers (*Chamaemelum recutica* L.), calendula flowers (*Calendula officinalis* L.), and flowers and leaves of St. John's wort (*Hypercum perforatum* L.).

Dye extraction - Dry leaves and flowers of the plants and shredded bark and peels were used for dye extraction. Leaves and flowers were treated in water at a bath ratio of 1:20 at 100°C for 60 minutes. Oak bark and walnut shells were stored in warm water for 4 days before treatment and then treated at 100°C for 120 minutes. After treatment, the plants were left in the bath for 24 hours at summer outdoor temperature. As the volume of water is reduced by evaporation and adsorption, the volume of the bath is replaced by the initial volume. Finally, the water extract was stored in a refrigerator.
Pre-treatment of wool with metal salts (mordants) - Pretreatment of wool with metal salts was carried out at 100°C for 60 min with addition of 2% metal salts (on the weight of textile material) and 5 g/l tartaric acid $C_4H_6O_6$ (pH 4.5). Metal salts are useful as mordants: copper(II) sulfate pentahydrate p.a. $CuSO_4{\cdot}5H_2O$, potassium aluminum sulfate dodecahydrate p.a. $KAl(SO_4)_2{\cdot}12\ H_2O$ and iron(II) sulfate heptahydrate p.a. $FeSO_4{\cdot}7H_2O$; (Kemika, Zagreb, Croatia). To achieve uniform processing considering the wool volume, the process was carried out with a bath ratio of 1:50. After processing, the wool was left in the bath for 60 minutes.

Dyeing of wool in plant extract - Dyeing in an aqueous plant extract was carried out at a bath ratio of 1:50 for 60 minutes at 100 °C and for 30 minutes at a temperature of 60 °C. The acidic medium (pH 4.5) was adjusted by adding 5 g/l tartaric acid C4H6O6 (Kemika, Zagreb, Croatia). After treatment, the wool was left in the extract for one day, then thoroughly washed in warm water, drained and laid out to dry (at summer outdoor temperature).

2. Felting

Creation of a color map - In the first phase, a color map with 19 color shades was created using the wet felting process (Fig. 2).

Fig. 2 – Color map
(Legend: 1 – walnut + Cu; 2 – walnut + Al; 3 – walnut + Fe; 4 – yarrow + Cu; 5 – nettle + Fe; 6 – nettle + Cu; 7 – nettle + Al; 8 – oak + Al; 9 – oak + Fe; 10 – oak + Cu; 11 – chamomile + Al; 12 – chamomile + Fe; 13 – chamomile + Cu; 14 – marigol + Cu; 15 – marigol + Fe; 16 – marigol + Al; 17 – St. John's wort + Cu; 18 – St. John's wort + Fe; 19 – St. John's wort + Al

Creating of felt pictures - Felt pictures are made by combining the techniques of wet felting (rubbing and soaping) (Fig. 3) and dry felting (with a needle) (Fig. 4).

Fig. 3 – Wet felting

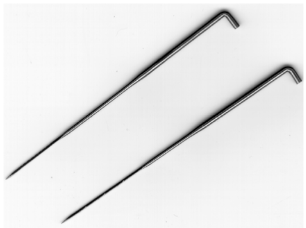

Fig. 4 – Needles for dry felting

3. Color measurement

The color coordinates of dyed samles were determined on spectrophotometer Datacolor 850, Switzerland under illuminant D65, using d/10 geometry. The coordinates used to determine color values are L* for lightness, a* for redness (positive value) and greenness (negative value), b* for yellowness (positive value) and blueness (negative value), C* for chroma and h for hue angle in the range of 0 to 360.

4. Color fastness testing

Dyed samples were tedstd to wash and light fastness. *Wash fastness* test was performed in a laboratory type machine for wet and dyeing processes Polycolor, Mathis, according to standard EN ISO 105 - C06: 2010: Textile - Color fastness test - Part C06: Stability of dyeing in household and commercial washing. The washing bath contained 0.5 g/l nonionic surfactant Kempon 30 (CHT Bezema) with liquor ratio 1:30 at 30±2 °C and pH 6 for 30 min. *Light fastness* test was performed according to standard ISO 105-B02:2014(en) Textiles - Tests for color fastness - Part B02: Color fastness to artificial light: Xenon arc fading lamp test. The test was carried out on the apparatus Xenotest 150 Atlas, in duration 30 min, corresponding to 5 h of illumination in natural conditions. The results of color fastness have been obtained objectively and are presented as total color difference values (dE) calculated according to CIELAB (CIE76) formula:

$$dE_{CIE76} = ((dL^*)^2 + (da^*)^2 + (db^*)^2)^{1/2}$$

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Results and discussion

Color map evaluation - Before starting the creation of felt images, the color map was evaluated. This included determining the color parameters (Tab. 1) and determination of the color fastness to washing and sunlight (Fig. 6.) This procedure is necessary to ensure not only the esthetic but also the functional value of the final product.

Tab. 1 - Coloristic parameters of color map (Fig. 3)

Sample	L*	a*	b*	C*	h
1 – walnut + Cu	51.36	2.83	13.88	14.16	78.47
2 – walnut + Al	56.44	3.79	15.08	15.55	75.90
3 – walnut + Fe	37.63	3.65	11.85	12.4	72.86
4 – yarrow + Cu	50.13	2.17	31.36	31.43	86.04
5 – nettle + Fe	26.05	2.55	9.15	9.50	74.41
6 – nettle + Cu	39.89	2.00	21.19	21.29	84.60
7 – nettle + Al	53.71	1.12	14.24	14.28	85.49
8 – oak + Al	48.06	7.04	20.76	21.92	71.27
9 – oak + Fe	40.07	10.76	19.74	22.48	61.41
10 – oak + Cu	42.06	7.75	20.29	21.72	69.09
11 – chamomile + Al	56.47	4.26	41.26	41.48	84.11
12 – chamomile + Fe	43.56	1.90	12.63	12.77	81.46
13 – chamomile + Cu	49.93	6.90	36.91	37.55	79.41
14 – marigol + Cu	49.58	0.34	25.90	25.91	89.24
15 – marigol + Fe	49.58	-0.93	18.29	18.32	92.90
16 – marigol + Al	56.99	1.36	24.59	24.63	86.82
17 – St. John's wort + Cu	40.65	5.43	22.08	22.74	76.17
18 – St. John's wort + Fe	36.31	6.90	21.33	22.42	72.09
19 – St. John's wort + Al	44.80	3.69	31.57	31.78	83.33

The used natural plant dyes are flavonoid dyes (Latin flavus - yellow), a group of polyphenolic compounds found in plant seeds, fruit bark, tree bark, leaves and flowers. The presence of flavonoid compounds is evident from the obtained hues h (Tab. 1), whose values range from 61.41 to 92.90. During dyeing with plant dyes, the flavonoid component (polyphenol) from the extract forms a colored metal complex. Salts of heavy metals (mordants) are needed to form dye-fiber bonds. Flavonoid dyes belong to the group of acid-wetting dyes. In acidic media, flavonoids ionize at the imide, carbonyl and hydroxyl groups. Depending on the textile raw material, the choice of metal salts (mordants) and the chemical structure of the flavonoid compounds, metal complexes of different colors are formed by ligand formation: fiber-metal ion natural dye (Fig. 5) (Sutlović *et. al.* 2020). In this way, samples with a wide color spectrum were obtained. It is also observed that for the same plant, samples with higher lightnes value and chromaticity are obtained when aluminum pre-treatment is performed. However, to obtain darker shades with lower chromaticity, pre-treatment with iron must be performed.

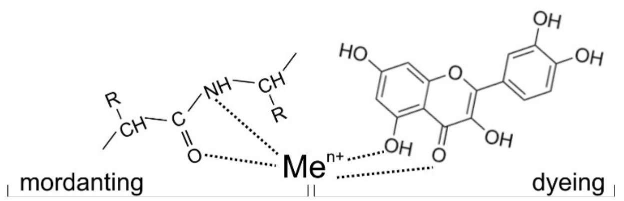

Fig. 5 - Schematic image of ligand formation: fibre—metal ion—natural dye

The test of color fastness to washing and sunlight (Fig. 6) showed that calendula and St. John's wort are the best, followed by walnut and oak. Nettle and chamomile show weaker stability, dE is greater than 10 compared to untreated samples. However, considering that the function of the felt is primarily esthetic, it can be said that acceptable properties were obtained, which can be further optimized by concentration and type of mordants.

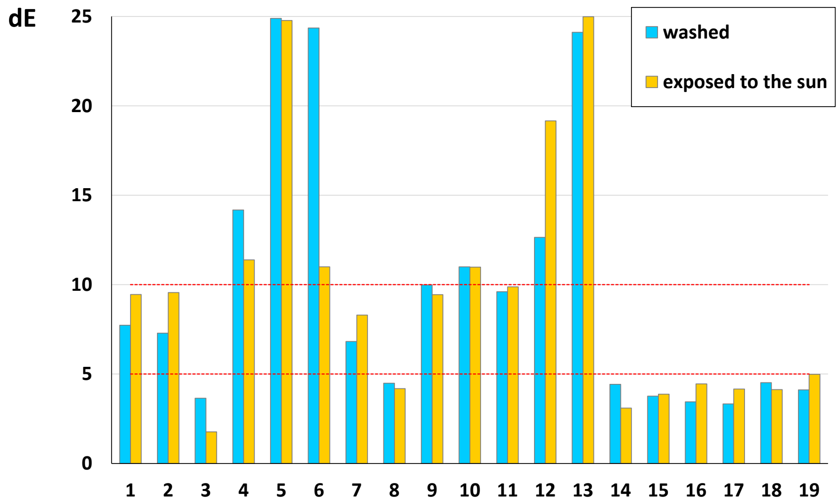

Fig. 6 – Color fastnes of color map (Fig. 3)

Felted pictures - Five images - multicolored representations - were made from undyed and dyed wool from Cres using the felting technique (Fig. 7). The felted pictures are inspired by the flora and fauna of the island of Cres. By combining different felting techniques, different effects were achieved, e.g.: Reliefs, three-dimensionality, effects achieved by color tones and their laying, sharp contours, smooth colors, etc.

a. „Tramuntana forest“

b. „Forest magic“

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c. „Macaklin lizard“

d. „Pramenka sheep“

e. „Reality or dream“

Fig. 7 – Felted pictures

The relief effect (Fig. 8) - was obtained in different ways. It is one of the ways of using semi-felt. Half-felt is half-felted wool from which the desired shapes can be precisely cut. In the example of the work "Reality or dream", the figures (sheep) were previously cut in half-felt and then felt again with the base (Fig. 7). This is how the depth of the display is obtained, that is, the effect of shallow relief, because the figures are more prominent than the landscape background on which they are located. Some of the sheep's characters are additionally emphasized with color, by using pure white merino wool and natural brown wool. The same example can be seen in the production of drywall and trees, which are also made of semi-felt. An example of shallow relief can be found in the work "Tramuntana forest". The flat representation of the tree motif is additionally protected with a felting needle, so that all contour lines are punched out with a needle (Fig. 8). In addition to the fact that more precise lines and a more realistic representation were achieved, at the same time the surface stability became slightly embossed. This also provided a tactile experience of the work. With a felting needle, the already existing lines of a character can be emphasized, and new lines can be created that enrich the appearance of a motif (such as the appearance of a leaf). In the work "Forest Magic", the relief effect was achieved by cutting the multi-colored layers of wool in depth and adding the cut part to the uppermost layer of wool using the needle felting technique. In this work, greater relief differences were obtained, because in addition to the parts that are more protruding than the surface, there are also depressions on the surface of the felt. Three levels were obtained: indentations created by incising, the initial surface of the felt, and protrusions created by building up the cut parts on the initial surface of the felt. A greater difference in the relief results in a different refraction of light, which in this work further enriches the presentation of the harmony of all tones.


Shallow relief achieved using semi-felt


Shallow relief achieved with a felting needle


Deep relief achieved by cutting and building

Fig. 8 – Relief effect

Striving to achieve a *three-dimensional effect* (Fig. 9), along with the basic technique of felting in the work "Tramuntana forest", the technique of inserting linoleum inserts was combined. They prevent the individual layers of wool from being felted, and after felting they are removed with the help of scissors. This is how it was achieved that the tree, coming out of the plot, "leaves" and better evokes the beauty and richness of the Tramuntana forest on the island of Cres. In addition to the tactile experience of three-dimensional leaves, the specialty of this work is the possibility of subsequent intervention, i.e. changing the position of the leaves, which results in new shades in correlation with the light. The same example can be seen in the making of the Sun.


Three-dimensional leaves


Three-dimensional sun

Fig. 9 – Three-dimensional effect

Examples of sharp outlines (Fig. 10) can be seen in the work "Macaklin lizard". Sharp outlines cannot be obtained simply by placing the wool on the support with the hands when arranging the desired motif. Sharp, precise shapes are obtained by using a felting needle (before wet felting) to arrange the fibers in a precisely defined location. By using the darkest shade (natural dark color of wool) for the contours and the natural white color of wool for the background, i.e. the background, a great contrast was achieved, which helps to make the figure depicted more prominent. In this way, sharp lines were used to achieve a more realistic representation of the subject with increased expressiveness (seen, for example, in the lizard's fingers and eye, which is further emphasized by an extremely white temple.


Getting sharp lines with a felting needle


An example of realistic rendering

Fig. 10 – Sharp contours

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To achieve the effect of smooth colors, similar tones are superimposed in such a way that it is not clear where each color begins and ends. In this way, shading (Fig. 11) and soft color transitions are created while maintaining the richness of the colors used. This can be seen in the depiction of plants, where individual plants, earth or stones are recognizable, but individually are not overemphasized, but form a unified whole (e.g. the work "Reality or dream"). This technique is particularly suitable for the representation of more complex motifs. In some works, natural, undyed wool was used as a base, which was left as the background of the artwork, helping to emphasize the representation of the motif. An example of this is the work "Macaklin lizard", in which the figure of the lizard is maximally emphasized by the choice of a dark, alternating color for the outlines and white for the background. In the design of the work "Forest Magic" no white background is used, but the entire work consists of layers of colored wool, so that no part is overemphasized in color. All colors are presented in a uniform tonal way, without details being emphasized by outlines or a white background, and we see the work as a tonally balanced whole.

Color gradients in the representation of plants, earth and stones

Color gradient in the shading effect

Fig. 11 – Effect of smooth colors

Conclusion

It is of great importance to draw attention to waste materials that surround us and that can be used as raw materials. This work is about waste wool, and plant waste as a source of dyes. Natural vegetable dyes were used to dye the wool, obtaining a very harmonious spectrum of earth tones. The obtained tones have a soothing and pleasant effect on the eye of the beholder and are very grateful for the realization of artistic achievements. The color fastness to sunlight and washing was also tested, and the results obtained are satisfactory considering the function. The works of art inspired by the landscape of Cres, realized with the felting technique and enriched with natural dyes, represent a valuable contribution to the preservation and popularization of the felting technique. Moreover, considering the chemical-morphological properties of wool and the properties of natural plant extracts, these products can find pharmaceutical-medicinal applications and certainly contribute to the tourist offer of the island of Cres and the wider ecological-ethnic offer.

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UrbanCroma, Chromatic Methodology, the results of a post-Doctoral research

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Abstract
This paper presents UrbanCroma, a chromatic methodology implemented during a post-Doctoral theoretical-practical work. This methodology was firstly developed during a PhD. The main aim of the post-Doctoral applied investigation was to test and validate this new methodology. With this purpose it was used in urban furniture chromatic plannings for two Municipalities in the Lisbon surroundings: Oeiras and Loures. UrbanCroma mainly intention is to be applied in the elaboration of chromatic plans for urban furniture, whose needs do not completely correspond to those proposed by other existing methodologies, destined almost exclusively to be applied to the built environment. Therefore, its chromatic plans allow the full performance of Urban Furniture functions, improving its use and transforming it in a factor of inclusivity, as its elements will become more visible and legible. Simultaneously, this methodology works as a factor of identification and orientation, since its elements will constitute harmonic chromatic sets that, although establishing a strong contrast with the surrounding environment, identify the neighborhoods or urban areas and, by their variation, constitute orientation landmarks throughout the city. In the research process, were chosen three different localities in each one of the Municipalities which constituted the case studies, where the UrbanCroma application starts by choosing samples areas, which will encompass the case studies most representative zones, applying there the new methodology to all furniture elements, in order to increase their potentiality as relevant issues for city color planning. In all these intervention areas, all the colors present in the environment are recorded, being it built or landscape, taking in account all the changes due to climatic variations and the non-permanent colors, whose presence has enough importance to be considered as environmental colors. All these colors were, then, registered in files and maps, in order to create a data-base allowing the identification of all environmental colors. The set of these colors permitted the establishment of the local dominant colors and, these ones, along with the contribute of the local history and culture, constitute the scientific basis upon which, it was established a very comprehensive urban furniture chromatic plans for both case studies. In complement, as each locality had a correspondent in the other municipality, it was also possible to compare the different urban plans included in the research.

Keywords: color, methodology, urban furniture, inclusivity.

Introduction

This paper presents and describes UrbanCroma, a chromatic planning methodology which was developed as part of a theoretical and practical work carried out during the research for a PhD thesis, whose main aim was to prove that a careful Chromatic Planning applied to Urban Furniture, in addition to increasing its visibility and perception, can also transform it into a factor of Inclusivity, Orientation and Identification. Posteriorly, the methodology was used in post-Doctoral applied research in order to be tested and validated, so that it may be applied whenever there is a need to create a chromatic plan for Urban Furniture, at a national or even international level. With this intention, UrbanCroma was tested in three case studies in each one of two municipalities near Lisbon − Loures and Oeiras.

UrbanCroma

As a methodology, UrbanCroma, has the particularity of being mainly intended to applied in the elaboration of chromatic plans for urban furniture, allowing the full performance of its functions, improving its use, and transforming it in a factor of inclusivity, as its elements will become more visible and legible inasmuch as they stand out from the surrounding environment, whether being it a built or a landscape. Likewise, this methodology has an identification and orientation function, since its elements will constitute harmonic chromatic sets that, although they establish a strong contrast with the surrounding environment, respect the local chromatic traditions, the place memory, identify the neighborhoods or urban areas and, by their variation, constitute orientation landmarks throughout the city.

1. The methodology steps

In order to identify the existing or present colors in each urban area and consequently identify the best chromatic contrast, the methodology establishes the following steps:

a. Definition of a sampling route for the chosen urban area, including the main streets and squares, and also some secondary streets, with the intention of encompassing the most representative areas of the above-mentioned. On the defined route, an extensive direct observation must be carried out, in order to estimate the presence of elements of urban furniture and signage, and to evaluate their visibility and legibility, as well as their chromatic applications (Gamito and Moreira da Silva. 2012), (Fig.1).

Fig. 1 –Examples of sample routes. Source: Margarida Gamito, 2022.

b. Then, along this route, an exhaustive survey of all the colors from the built or landscape environment is carried out, as well as all the colors of the existing materials and textures. In these records, are also included samples of the chromaticism of the pavements, vegetation and all other elements present in the urban environment, with a relative permanence, which constitute the non-permanent colors, that must be considered for the chromatic reading of the space. In addition, are taken in account all the changes due to climatic variations (Gamito and Moreira da Silva, 2012). Considering the possibility of human error, due to the subjectivities of each observer's vision, and in order to achieve a greater objectivity and rigor in the collection, the chromatic survey must be performed by more than one observer, crossing the various observations.

c. All these photographically registered and, simultaneously, identified according to the Natural Color System (NCS) notations, the system chosen for this methodology, as it allows the easy identification of any color without using additional equipment, even if it is not easily accessible. We must also underline that the registered colors are perceived colors, not always coincident with the inherent ones and that, in the particular cases of different varieties of vegetation and tiles covered walls, the perceived colors are partitive syntheses of the present colors (Fig. 2).

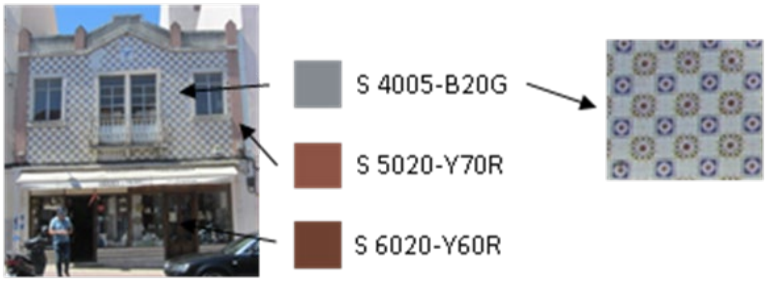

Fig. 2–Examples of a building registered colors. Source: Margarida Gamito, 2022.

Fig. 3 – Examples of panoramic views. Source: Margarida Gamito, 2022.

d. As a complement, and for a better chromatic identification of the case study, photographs of the surrounding elements and panoramic views of the different blocks are used whenever justified, as components of the environmental color. All these collections are methodically indexed in files, designed expressly for this methodology, in order to create a scientific base where all the colors present in each street, area or square of the sample route are indexed, with the percentages corresponding to their presence, which makes it possible to identify all the environment colors and, then, determine a dominant chromatic palette for each We must highlight that the designed file is an important part of the methodology, since it allows the identification and visualization of all the chromatic information, allowing an easy analysis and interpretation of all the data collected (Fig3).

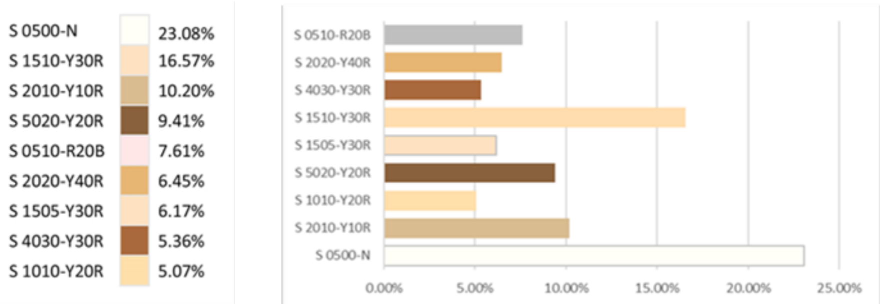

Fig. 4 – Examples of an urban area dominant colors Source: Margarida Gamito, 2022

e. The dominant chromatic palettes of each neighborhood, or urban area, in turn, lead to the establishment of a coherent chromatic plan that should be applied to the urban furniture of the city. This chromatic plan, which is different for each neighborhood or urban area, must respect the local history and tradition, and establish a chromatic contrast with the surroundings that will allow urban furniture to stand out and contribute to a better legibility of its elements, that will become identifying factors, which will facilitate orientation within the city (Gamito and Moreira da Silva, 2012). In order to achieve a scientifically well-founded color plan with chromatic coherence, it is considered essential, at this stage of the work, to have the collaboration of Specialists in Color Symbolism, Historians, City Councilors, among others, who will be responsible for the decisions concerning the application of this methodology, given that it is a multi-disciplinary work (Gamito and Sousa, 2017), (Fig.4).

2. UrbanCroma Module (MUC), the methodology metric unity

The colors recorded in the chromatic survey of the different urban areas, constituting the case studies, are often outside physical range, which prevents a measurement in the traditional way. Thus, due to this difficulty and in order to establish the proportionality of the colors present in each neighborhood/urban area, the UrbanCroma Module - MUC - was created. This Module, that corresponds to the area of a wall with the height of one floor and wide enough to encompass a door and a window, includes subdivisions that allow the evaluation of smaller areas dimensions. The application of this module to the facades, in the appropriate scale, allows the definition of the percentage each color is present in every building and, by sum, in each street and urban area (Fig.5).

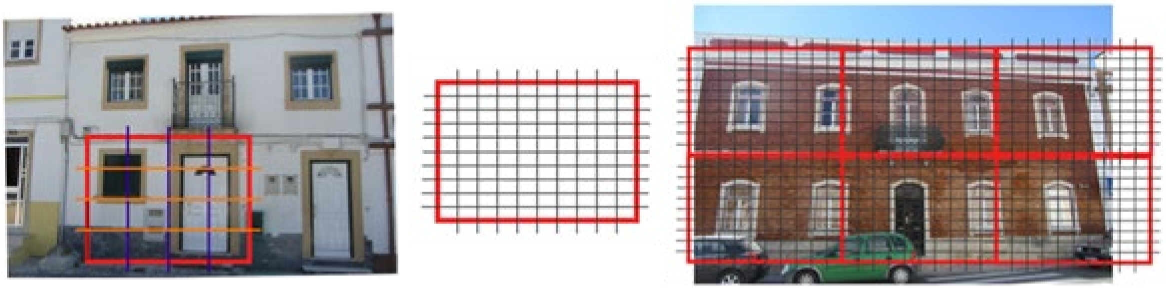

Fig. 5 – Definition of MUC and its application in the color measurement of a building. Source: Margarida Gamito, 2022

Loures and Oeiras, the UrbanCroma case studies

The two chosen municipalities in the Lisbon (Portugal) surroundings are: Loures, a municipality away from the river Tagus and constituted by traditional, modern and rural settlements; and Oeiras, a municipality that has settlements both on the interior and on the sea front, being at the same time a miscellanea of old and modern. In order to apply the UrbanCroma methodology, were chosen three different localities in each of these municipalities with different dimensional, anthropological and topographic characteristics. These locals, that encompass social neighborhoods, traditional settlements and modern building urbanizations, inevitably have several characteristics which allow the application of this methodology to a wide range of neighborhoods, but in a certain way are similar in each of the municipalities. So, the case studies consist of:

a. Villages or urban areas where architecture has evolved over time, constituting a cluster of traditional and modern buildings, from which the **Centre of Loures** and the **Historical Centre of Carnaxide** (Oeiras) are examples. The Centre of Loures is the urban area of the municipality where the City Council and the main administrative services are based. Despite its current development, it still maintains a historic character and a great variety in its buildings that mark its evolution over time. The Historical Centre of Carnaxide, is one of the oldest documented pieces of land in Portugal, with large historical buildings, and other ones that still maintain its characteristics as an old village (Gamito and Sousa, 2019).

b. Traditional villages that have maintained the same character over time, with buildings rarely exceed two floors ─ **Bucelas** (Loures), a very old village with evidences of human presence since Celtic times, that is a rural village, with no relevant industries, with the exception of those related to wine production; and the locality of **Laje**, which is the most complex of these case studies, being composed by three different urban zones: social housing, an urban zone constituted by several buildings, all similar and belonging to the municipality, to whom the inhabitants pay a rent; own housing, a group of plots that were sold to the residents by the municipality with the architectural project included; and AUGI, which means that those are plots without a municipal permit were the population have built their residences and, then, they were recognized as urban areas.

c. Modern urban areas, with tall and modern buildings, constructed from scratch, with their own architectural planning — Infantado Urbanization (Loures), and Modern Carnaxide (Oeiras).

Conclusions

The analysis of the case studies allowed us to verify the predominance of white and light tones, in all of them. Therefore, the color choice for the urban furniture chromatic plans must fall on high saturated colors that will allow the establishment of the necessary chromatic contrast with the light colors of the surroundings.
Besides the UrbanCroma validation, the study cases diversity, also made it possible to cover a greater extent of possibilities for the application of this methodology, as a result of having fallen into areas with similar characteristics in both municipalities. Thus, it was possible to establish a comparison and verify that this methodology was perfectly suited to any of the cases and, therefore, could be extended to other types of application.
Likewise, the research analysis allowed to conclude that although UrbanCroma was created and developed to be used in Urban Furniture, with the function of highlighting it from its surroundings, it may have a more generalized application. It may, among others, be indicated for: create chromatic plans for new urbanizations, both in terms of architecture and urban furniture; whenever you want to establish chromatic contrasts or harmonies in any space, indoors or outdoors; every time you want to apply a color to an element, or set of elements that you want to stand out from the environment; and, with the opposite purpose, it can also be applied whenever it is intended to integrate or merge any element in its surroundings (Fig. 6).

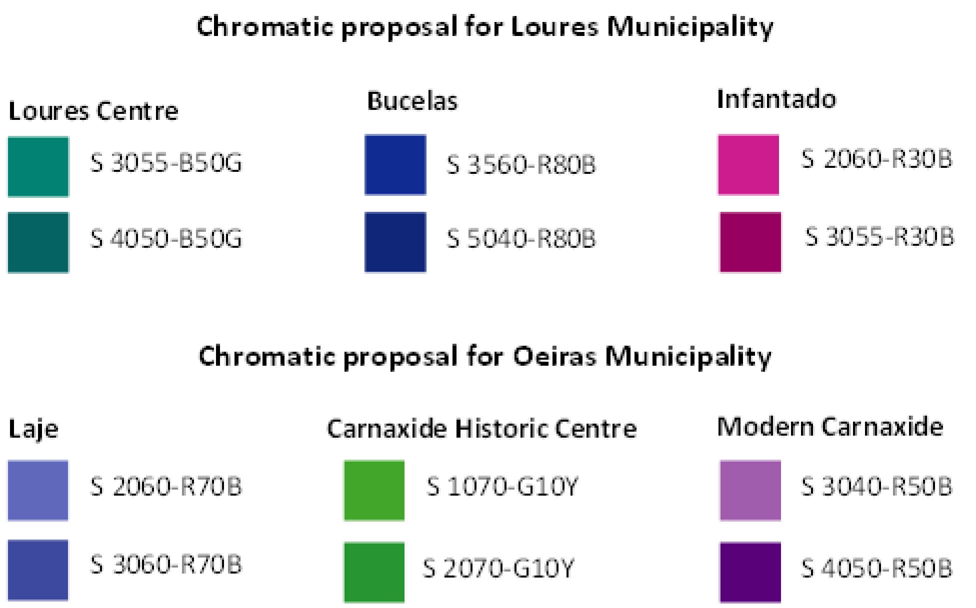

Fig. 6 – Chromatic proposals for the different case studies Source: Margarida Gamito, 2022

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Plants out of place? A design-driven investigation of colour and material possibilities within a group of "invasive alien plant species" in a Norwegian context

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Abstract

How do we plan and facilitate the production of goods and services for a growing human population, living on an altered and depleted globe? The climate crisis and biological mass extinction, the global pandemic and the unstable political landscape all indicate an urgent need to re-think production and consumption. Although this may seem like an overwhelmingly complex task, we are witnessing a positive trend towards innovative and visionary thinking across disciplines. Design is a field that bridges industry, crafts and science. Through its functionality, creativity, and storytelling, design has the potential – and responsibility – to be an engine for transformation. Thus, belief in and a drive towards concepts and visions for regenerating, reconnecting and rebuilding has been an essential force and leading perspective from which the PhD project "The Settlers – towards new territories in design" has been conducted.

The Settlers is a practice-led research project that questions attitudes and regulations concerning so-called "Invasive Alien Plant Species" (IAPS). While the term "weed" can be used to describe any plant growing in a place where it is not wanted, IAPS is commonly used to label non-native plants that become overpopulated and adversely impact their new environments, causing economic or ecological damage (Orion, 2015). From this perspective, removal and eradication seem like an obvious solution. Yet could this effort and intervention also cause economic or environmental damage? And what do we lose when we ignore, weaken or destroy these plants?

As a take on this complex situation, The Settlers approaches IAPS as new local plants from which we can learn, and with which we need to establish new relationships, in order to achieve a healthier future coexistence. By seeking and gathering stories regarding their edibility, environmental benefits, health benefits, colourants, fibre and wood applications, a new landscape of knowledge and understanding has emerged. Mapping and sorting this information have created the starting point for practical exploration.

This paper focus on the preliminary results regarding colourants for textile dying represented by the IAPS in Norway. Examples of textile dying with various mordants, and colour-extractions, serve to materialize and validate the collected data, and present the beautiful colour varieties of these plants. There is a particular focus on the results of the Japanese Knotweed, *Fallopia japonica*.

Keywords: Design, Invasive Alien Plant Species, Colour applications, Textile dyeing, Circular Economy, Fallopia japonica.

Introduction

As in most parts of Europe, the knowledge of dyeing with natural pigments has a long history in Norway. Early findings of plant-dyed cloth dates back to the Late Roman Iron Age (Jørgensen and Walton, 1986; Lukešová, 2017). It is assumed that mostly local plants were in use at this time, although the red colorants alizarin and purpurin from Madder, *Rubia tinctorum*, and the blue colourant indigotin from Woad, *Isatis tinctoria*, has been identified in various textile samples (Jørgensen and Walton, 1986; Lukešová, 2017). Woad seeds from 834 A.D. were found at the Viking Age ship burial site at Oseberg (Sagberg, 2017). It has also been proven that local variations of madder-like red dyes have been used, such as Bedstraw, *Galium verum L.*, and Northern

Bedstraw, *Galium boreale L.*, as well as a whole range of local, unidentified, yellow dyestuff (Jørgensen and Walton, 1986). For centuries, natural dyes were the main colourants accessible for textile dyeing, yet with the development of synthetic dyes at the beginning of the twentieth century the interest in and further development of natural dyes stagnated (Bechtold, 2003). In Norway, Hilda Christensen was one of the first to gather and preserve the knowledge of the old dye traditions (Sagberg, 2017). Her textbook *Lærebok i farging med planter* ("Textbook on dyeing with plants") on natural dyeing was published 1908. In it, she presented recipes containing imported dyestuffs, like cochineal, indigo and madder, yet her focus was mainly directed towards local barks, leaves, twigs, herbaceous plants, and lichens, most of which are still viable in the Norwegian flora today. Hundred years of producing synthetic dyes, have had a huge impact on environment and humans. Over the years also the landscape and flora has been drastically transformed and makes the starting point for gathering and harvesting today very different than it was for Hilda and her contemporaries. Visual changes in the landscape, like expanded urban, agricultural and industrialized areas, infrastructure and power masts are evident even at a distance. Others must be experienced, like certain climatic changes, or discovered up close, like the range of new species (UNEP, 2021). Since 1800 more than two-thousand non-native alien plant species have settled in the Norwegian flora (Artsdatabanken, 2018). These are, for better or for worse, an existent part of the living landscape surrounding us. This new point of departure makes the necessity to rethink, restructure and re-establish our relationship with the environment seem apparent.

Although most IAPS in Norway have been introduced as ornamental plants, some have long histories as cultural and useful plants elsewhere (Artsdatabanken, 2018). Plants which are labelled as invasive in one place may be appreciated or protected in another context. Dyer's Woad *Isatis tinctoria,* has for instance been a sought- after resource throughout history. Today is has pest status in some western states of the United States, while in the UK it is being re-introduced as a commercial dyestuff and cultivated as a such (Moore, 2019; The Woad Centre, 2012). Similarly, Japanese Knotweed, *Fallopia japonica*, one of the world's most invasive species, is valued in countries where it has cultural purposes. In Japan and China, it has been used as a traditional medicine for centuries (Shaw, 2013). Its root is a rich source of resveratrol and is sold in nutritional supplements, and its young shoots are consumed as a vegetable (Shaw, 2013).

When the practice-led PhD-project "The Settlers – towards new territories in design" started at the University of Bergen, Faculty of Fine Art, Music and Design in 2018, the first case study and following exhibition, *Interpreting Fallopia japonica* (Fig. 1) presented a design-perspective on Japanese Knotweed, focusing on materials and colours. A range of warm yellows to ochre and golden brown were achieved by boiling its rhizomes without mordants.

Fig. 1 – The Exhibition *Interpreting Fallopia japonica* at Joy Forum in Bergen, April 2019.

At the time, only one research was found on colours and pigments from IAPS, NYC based artist Ellie Irons watercolour project "invasive pigments" (Beans, 2018). But in the following years an increased focus on the topic resulted in interesting studies and projects world-wide. To mention

some: Alyssa Dennis based in Maryland (US) has started the "Invasive Apothecary", where she works with IAPS as a part of her multidisciplinary art and clinical herbal pharmacy practice (Dennis, 2022), UK-based Marina Belintanis devoted her MA degree to material research on Japanese Knotweed (RCA, 2020), and the city of Ljubljana has made a major investment concerning the handling of IAPS, called the Applause project (Urban innovative action, 2020). Based on the motto: "from harmful to useful", citizen-led activities have approached new circular economic and social systems. From the University of Ljubljana, two papers concerning colour extracts from Japanese Knotweed have been published: *Screen printing with Natural Dye Extract from Japanese Knotweed Rhizome* (Klančnik et al., 2021) and *Cationic Pretreatment of Cotton and Dyeing with Fallopia Japonica Leaves* (Gorjanc et al., 2019). The book, *True colors, world masters of natural dyes and pigments* (Recker, 2020), presents the story of Avani, a community-driven non-profit organization in India. Their mission is to bring back community, local textile production and responsibly made goods. Research on regional dyestuff revealed that a local pest plant, *Agerationa adenophora*, could yield a range of yellow and green dyes (Recker, 2020). Through regular harvesting, thereby removing the plant from the woods, the community helps balance the local ecosystem, which was suffering by the invasion of this plant. At the same time, the community accesses a wild growing dyestuff which is plentiful.
These examples are intriguing indications of a shifting mind-set towards sustainable economic and social systems, based on holistic handling of IAPS as natural resources.

Selection of plant material
The Settlers is focusing the research on the 73 IAPS labelled with the "highest risk assessment" (Artsdatabanken, 2018). Through a mapping of historical and present day usage of colour extraction, descriptions or indications were found regarding more than 60% of the group: 45 plants. This has been the starting point for the following practical colour study. Although the tests were performed as dyes for textile the palette can hopefully be useful for a broader field.
Fig. 2 gives an overview of the 45 plants and their status after the quantitate and qualitative analyses. The studio tests resulted in samples made with 24 plants, selected based on the collected information and availability.

Experimental
Hilda Christensen's textbook *Lærebok i farging med planter* has formed the basis for the recipes and process of making the dye samples. It must be emphasized that these are studio experiments and not lab-tests. Chemical components, lightfastness, wash fastness, and a systematic treatment of each single dyestuff have not been examined. In this early-stage study, the focus has been on outlining the palette.

Plant material – storage and extraction
Although the study was planned for spring/summer 2020, there was a two-year delay due to covid-19. This has affected harvesting and storage as some of the plant material already prepared had to be stored and dried. In addition, the fact that it is not always possible to plan harvesting and processing has caused a variation of fresh and dried processed plant material. This is indicated in Fig. 2. Before extracting the dyestuff, the plant material has been cut into smaller pieces of random sizes. The exception is smaller flowers, like Large-leaved Lupine, *Lupinus polyphyllus,* and Dotted Loosestrife, *Lysimachia punctata*, which have been boiled as they are.

Fibre for testing
Each sample consists of four 60 cm long pieces of 100% pure neutral white wool yarn.

PLANT	PART	CONDITION	TESTED	COLOUR (INDICATION)	ALUMINUM SULFATE	AMMONIUM CHLORIDE	POTASSIUM CARBONATE	IRON(II) SULPHATE	PLAIN VINEGAR
1. ALASKAKORNELL / Red-osier Dogwood / *Swida sericea*	Twig	Fresh	June	Yellow / Grey	x				
2. ALPEASAL / Mougeot's Whitebeam/ *Sorbus mougeotii*	Bark	-	-	Yellow / Brown					
3. ALPEFURU / (buskfuru)/ (Swiss) Mountain Pine / *Pinus mugo* (**VRIFURU / Lodgepole Pine / *Pinus contorta*)**	Needle Cone	- -	- -	Green Brown					
4. ALPEGULLREGN / Scotch Laburnum / *Laburnum alpinum*	Flower / Leaf	-	-	Yellow					
5. BLEIKSPIREA / Meadowsweets / *Spiraea ×rubella*	Twig	Fresh	June	Apricot	x				
6. BLÅHEGG / Juneberry, Serviceberry / *Amelanchier spicata*	Berry	-	-	Purple					
7. BLÅLEDDVED / Fly Honeysuckle/ *Lonicera caerulea (var. Edulis)*	Berry	-	-	Purple					
8. BOERSVINEBLOM / Narrow-leaved Ragwort / *Senecio inaequidens*	Leaf Flower	- -	- -	Green / Yellow Brown / Orange					
9. BULKEMISPEL / Hollyberry Cotoneaster/ *Cotoneaster bullatus* (**BLOMSTERMISPEL** / Showy Cotoneaster / *Cotoneaster multiflorus)*	Leaf	Fresh	May	Beige / Brown	x				
(**DIELSMISPEL** / Diels' Cotoneaster/ *Cotoneaster dielsianus)* (**SPRIKEMISPEL** / Spreading Cotoneaster / *Cotoneaster divaricatus)*	Root	Fresh	May	Rose	x				
	Berry	-	-	Beige / Rose / Brown	x				
10. FAGERFREDLØS / Dotted Loosestrife / *Lysimachia punctata*	Flower	Fresh	July	Yellow / Green	x				
	Root	Fresh	July	Beige / Brown	x				
11. GRØNNPIL/ Crack Willow / *Salix × fragilis (Salix × rubens)*	Leaf	Fresh	July	Yellow / Green	x				
12. GULLREGN / Laburnum / *Laburnum anagyroides*	Bark Flower	- -	- -	Brown Yellow/ Orange					
13. GYVEL / Scotch Broom / *Cytisus scoparius*	Stem w/ buds	Fresh	April	Green	x				
	Flowering stem	Fresh	July	Green	x				
14. HAGELUPIN / Big-Leaf Lupin, Lupine / *Lupinus polyphyllus* (**JÆRLUPIN** / Sundial Lupine / *Lupinus perennis)*	Blue flowers	Fresh	July	Green/Turquoise	x				
(**SANDLUPIN** / Blue Lupine / *Lupinus nootkatensis)*	Stem / Leaf	Dried	July	Yellow	x				
15. HYBRIDBARLIND / Anglojap Yew / *Taxus x media*	Stem / Bark	Fresh	June	Apricot / Brown	x				
16. HØSTBERBERIS / Japanese Barberry / *Berberis thunbergii* / green leaves	Stem / Leaf	Fresh	July	Yellow / Grey	x				
− / red leaves	Stem / Leaf	Fresh	July	Apricot / Yellow	x				
17. JAPAN PESTROT / Sweet Coltsfoot, Butterbur / *Petasites japonicus*	Leaf	-	-	Yellow / Orange					
18. KANADAGULLRIS / (Giant-)Goldenrod / *Solidago canadensis (+ gigantea serotina)*	Flowering stem	-	-	Yellow / Green/ Grey	x				
19. KJEMPESPRINGFRØ / Himalayan Balsam / *Impatiens glandulifera*	Stem/ Leaf/ Flower	-	-	Ginger/ Brown					
20. KLASESPIREA / Meadowsweets / *Spiraea ×billardii*	Twig	Fresh	July	Rose	x				
21. KLISTERSVINEBLOM / Sticky Groundsel / *Senecio viscosus*	Leaf Flower	- -	- -	Green Yellow / Brown					
22. KRYPFREDLØS / Creeping Jenny / *Lysimachia nummularia*	Root	Fresh	Sept	Brown / Grey	x				
	Leaf / Stem	Fresh	Sept	Yellow / Beige / Grey	x				
23. MONGOLSPRINGFRØ / Smallflower Touchmenot / *Impatiens parviflora*	Leaf / Stem	-	-	Yellow					
24. PARKGULLTVETANN / Yellow Archangel / *Lamiastrum galeobdolon galeobdolon*	Leaf / Stem	-	-	Green / Beige					
25. PARKSLIREKNE / Japanese Knotweed / *Reynoutria japonica, Fallopia japonica*	Leaf	Fresh	May	Yellow / Ochre / Grey	x				
(**HYBRIDSLIREKNE**, Bohemian Knotweed / *Reynoutria x bohemica)*	Root	Fresh	July	Yellow / Orange Red / Green	x				
26. PLATANLØNN / Sycamore / *Acer pseudoplatanus*	Bark / Twig	Fresh	June	Beige	x				
	Leaf	Fresh	June	Yellow	x				
27. PRAKTMARIKÅPE / Lady's-mantle / *Alchemilla mollis*	Leaf / Stem	Fresh	May	Yellow / Green	x				
28. PURPURSPIREA SPIREA (Bjarkøyspirea) / Meadowsweets / *Spiraea x rosalba*	Twig	Fresh	July	Rose	x				
29. RYNKEROSE / Beach Rose / *Rosa rugosa*	Hip	Dried	July	Beige	x				
	Petal	Dried	June	Beige / Brown	x				
30. RØDHYLL / Red Elderberry / *Sambucus racemosa*	Berry	Dried	August	Beige / Green	x				
31. SKOGSKJEGG/ Goat's Beard / *Aruncus dioicus*	Leaf / Stem	Fresh	June	Yellow / Green	x				
32.SNØBÆRBUSK/ Common Snowberry /*Symphoricarpos albus (L.) S.F.Blake*	Twig	Fresh	June	Yellow / Grey	x				
33. SITKAGRAN (+Lutzgran) / Sitka Spruce/ *Picea sitchensis (+Picea ×lutzii)*	Needle / Twig	Fresh	June	Beige / Brown	x				
34. TROMSØPALME / (Persian) Hogweed / *Heracleum persicum, Heracleum tromsoensis*	Leaf / Stem	Fresh	June	Yellow / Grey	x				
35. VESTAMERIKANSK HEMLOKK / Western Hemlock / *Tsuga heterophylla*	Bark	Fresh	May	Brown	x				
36. VALURT / Comfrey / *Symphytum officinale*	Leaf / Stem	-	-	Green					
37. ULLBORRE / Woolly Burdock / *Arctium tomentosum*	Root	-	-	Green / Beige					

Fig. 2 – Plant sources, condition of dyestuff, mordants and range of colours. Fibre used for testing is 100% sheep wool, neutral white. Related plants, where the results are expected to be similar, are placed under the same number in this overview. The first name is the plant actually tested.

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Mordants

A broad variation in shade and colour depth has been achieved by applying the natural dyestuffs in various mordants. Alum has been used as a pre-mordant in a separate immersion bath for the fibres, while vinegar, ammonium chloride, iron and pot ash have been used as separate post-mordants.

1. Aluminium Potassium Sulphate, KAl(SO4)2·12H2O. Used to prepare fibres to accept colour. Mixed in a pot with tap water in a ratio of 100g fabric to 5 litres water and 20g Alum.
2. Vinegar, 7% acetic acid by volume. Not a colour shifter, but a fixer. Mixed with hot tap water at a ratio of 1:10 in the rinsing water.
3. Ammonium chloride, NH4CI, is a acidifying salt used as a substitute for previous use of stale urine. Ammonium chloride is added to hot tap water at a ratio 1:5, the fibre has been dipped several times before rinsing in water.
4. Pot ash. Potassium carbonate, K_2CO_3. An alkali mordant used as a colour shifter. The fibre is soaked 10 minutes in hot water of ashes, before being rinsed in water.
5. Iron(II) sulphate, $FeSO_4$+$7H_2O$. Ratio 4g per 100g fibre. Added the remaining dyebath, fibre boiled in the mixture for 15 minutes before being rinsed in water.

Christensen frequently used tin and copper in her recipes (Christensen, 1943). However, due to their toxic properties, they have been left out of this study. Other mordants she used, like cream of tartar, citric acid or soda will be considered for further development.

Dying

The dyestuff has been extracted with boiling tap water in a pot of stainless steel. The type of plant material varied from stems, twigs, leaves and petals to bark, hips and roots. In order to make working steps that could be applied to all the materials, and with the hope of gaining as clear and strong hues as possible, some safety margins were established regarding dyestuff-fibre ratio and time needed for the dyestuff to be absorbed by the water. These steps have been followed:

1. Dyestuff-fibre ratio: 10g sample fibre to a minimum of 50g dyestuff has been added to 2 litres of water.
2. Time: Dyestuff has been boiled in water and allowed to cool down and soak for 12-24 hours (flowers and soft, thin twigs and stalks were soaked for 12 hours, while hard, dry twigs, bark and roots were soaked for 24 hours) before adding the fibre and heating a second time. The fibre has simmered for 60 minutes before cooling down in the pot, together with the dyestuff.
3. The textile material has been split into 4 parts and treated with the different post-mordants as mentioned above.
4. After rinsing, the swatches were air dried in room temperature.

Results and discussion

This first colour mapping of IAPS in Norway was executed as a part of the PhD project "The Settlers – towards new territories in design" (Wilhelmsen, 2022). It presents the range of colours and hues of 45 different plants. Some plants have not been tested due to availability, others have been tested several times, focusing on different parts of the plant. Through using four different mordants, the study presents a total of 132 swatches, whereof yellows, greens, greys, beiges and browns are frequent examples. Apricot, rose and orange are fewer, while purple is only found twice, and one outcome shows turquoise and one red.

The results represent dyes from roughly 2/3 of the high-risk group and 2% of the total group of IAPS in Norway. But even this small selection shows a rich palette, which outlines a range of possibilities for further elaboration. Some colours stand out with bright and clear shades, like the yellows from Crack Willow, *Salix × fragilis* and Goat's beard, *Aruncus dioicus*, the green and turquoise from the Large-leaved Lupine, *Lupinus polyphyllus*, and the rose shades from the Meadowsweets shrub, *Spiraea × billardii*. Others are noteworthy due to their variety of shades, like the range of different greens made by Scotch broom, *Cytisus scoparius,* which change from yellow-green tones in April-May towards deeper greens and browns through the season. Iron proves to be a

strong colour shifter which demands further exploration in order to create a total overview of hues and a scheme for reproducing these. It produces dark browns, greys and greens. Ammonium chloride and ash water are alkaline additives, which tends to create warmer nuances.
Some dyestuffs don't react much on changing the acidity, such as the Sitka Spruce, *Picea sitchensis*, while others, such as the dyestuff extracted from Japanese Knotweed rhizomes, have proved to be pH-sensitive. This dyestuff shows the most remarkable colour shifts in the study. As mentioned, previous tests on Japanese Knotweed, including what is found in research and literature, shows a variety of warm yellows, to ochre and brown hues. Yet, this study has revealed drastic colour shifts on this dyestuff by changing the acidity or alkalinity of the dye baths. Adding iron it turns olive green, and it changes to hues of reds with alkalic agents. A test done without alum-treated fibres shows orange colours occurring with ammonium chloride and rose by using pot ashes. An additional experiment has tested the dyestuff in a 7-day cold-dye. The colours show the same variety, yet in softer and paler tones. Fig. 3 expresses the richness of hues obtained with Japanese Knotweed. As for all samples in this study, further tests are needed to define wash fastness, rub fastness and lightfastness. However, as an indicator the Japanese Knotweed swatches from 2018 have not changed after washing and still demonstrate colour of good, but slightly darker, quality.

PART	CONDITION	TESTED	TREATMENT	ALUMINUM SULFATE	AMMONIUM CHLORIDE	POTASSIUM CARBONATE	IRON(II) SULPHATE	PLAIN VINEGAR
Leaf	Fresh	May	Simmer: 1 hour + soak: 12-24 hours	x				
Root	Dried	–	Simmer: 1 hour + soak: 12-24 hours	x				
Root	Fresh	July	Simmer: 1 hour + soak: 12-24 hours	x				
Root	Fresh	July	Simmer: 1 hour + soak: 12-24 hours	–				
Root	Fresh	July	Cold dye in glass jar - 1 week	x				
Root	Fresh	July	Cold dye in glass jar - 1 week	–				
Root	Fresh	–	Simmer: 1 hour, washed (2018), post-mordanted 2022	–				

Fig. 3 – Japanese-, Giant-, Bohemian Knotweed / Reynoutria (Fallopia) japonica, Reynoutria sachalinensis, Reynoutria x bohemica. Condition of dyestuff, mordants and range of colours. Fibre used for testing is 100% sheep wool, neutral white.

Conclusions

As this deep dive into colours contributes to a larger context and investigation in the PhD project "The Settlers", the results are reflected in light of the opportunities revealed in involvement with the group of IAPS, or the new local flora, in Norway.
Indeed, the IAPS in Norway must be adaptable and robust as they are capable of thriving and successfully reproducing without cultivation in this rough climate and environment extensively changed by humans. They don't require fields, which potentially could be used for food crops, as these plants normally grow where the soil has been disturbed, abandoned or unmanaged. They typically grow in gardens, on green patches between houses, in backyards, along river banks and sidewalks – often in urban areas, where native plants can´t survive the harsh conditions (Orion 2015). Are these plants really "out of place" – and "out of control"? Or are they actually above all 'out of care' and neglected? Interacting with and utilising these landscapes and the plants that inhabit them reveals a possibility to activate abandoned and unmanaged areas of the city (in agreement with the landowner, which often may be the city or state) – and possibly even combining maintenance of vulnerable areas with harvesting material for dyeing, making lake-pigments or other colourants. Harvesting in this way could be time-consuming since it might involve moving from site to site. On the other hand, cultivating dye crops in a field would involve ploughing, seed bed preparation, and weed control (Bechtold and Mussak, 2009). Furthermore, replacing harmful and labour-intensive measures used to combat IAPS with knowledge and care could result in a natural reduction and balance based on utilisation, local production and circular economy.
Creating plant-based palettes, natural dyes, and site-specific recipes make it possible to generate dye from renewable natural sources, as opposed to synthetic dyes produced with substances from

non-renewable sources. The process can be a social practice, a local business or a forager's way of reducing consumption and collecting colourants for personal use. The harvest and preparation of dyestuff from local plants stimulates contemplation and connects us directly to the plants, and the environments and landscapes in which they grow. It is a way to get to know the plants –and to start developing a new relationship and collaboration. It is also a way of reconnecting with the past, with traditions passed on from artisans through history, and a path towards a balanced and fertile coexistence.
The colour study demonstrates that IAPS are promising dye plants for the future. If we overlook these plants, we will miss an opportunity to pair up with plants that can endure and thrive in a changing and demanding climate, securing sustainable local and renewable colourants and materials. What has been found in this study is a range of colours, which can achieve even further varieties. As mentioned, the results should be understood as indicators, more than absolute answers. Seen from a design-perspective, potential future applications include everything from textile dye production and the development of inks, lake-pigments, and food-colorants to the development of new paints for architecture and design, natural stained paper, colourants for cosmetics and pharmaceuticals, and tints for wood treatment.
The aim of this study has been to add new knowledge and insight from involvement with the group of Invasive Alien Plant Species in a Norwegian context, with transfer value to other communities and ecosystems. This can hopefully contribute to widening the range of information available and drawing further attention to the potential of pushing the boundaries of local resources and holistic planning of (any scale of) colour production.

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Colour Composition and Visual Tectonics in Facades; Adapting Colour Teaching to Current Architectural Practice

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Abstract
In Norway, this last decade has seen a steadily increasing demand for knowledge of how to use colour in an architectural context, and this paper will focus on the application of colour theory in building façade design. In architecture, colour theory is a body of practical guidance to the visual effects of a specific colour combination creating a logical structure for colour, how we can organize them, and how colours can be used to enhance architectonic intent. Current architectural education largely focusses on the *tectonic,* as in relating to building and construction, and on the formal aspects of the *visual tectonic,* but until very recently, the teaching has devoted little focus to the visual tectonics of colour. As most research estimates that approximately eighty percent of our perception, learning, cognition, and activities are mediated through vision, with form and colour being a key feature, it could be argued that we should put more emphasis on the visual qualities of colour of architecture, i.e., inherent or applied. This paper will discuss how developing an understanding of colour theory and implementation relevant to architectural education and practice in Norway is changing both students and professional practitioners' attitudes towards the use of colour in architectural projects, giving examples from the recent years colour teaching at NTNU and professional implementation by the authors.

Keywords: colour in architecture, colour theory, façade design, visual tectonics, advancing and receding colours

Introduction

The authors observe that the general paucity of colour understanding in architectural education and the profession leads to serious deficiencies in the built environment. The lack of knowledge of colours' actual qualities and functions across all architectural scales leads, at best, to an appeal to aesthetics without the necessary structural argument to convince developers or clients, and to "best guess" intuition late in a project without confidence in the outcome and with unpredicted and unfortunate effect. Often the colour knowledge gap means that colour is dismissed as merely a secondary phenomenon of little cultural or design importance resulting in an indiscriminate following of whatever trend is dominant. The authors along with other colleagues have worked to develop an educational structure that addresses these deficiencies.

"... to take an aesthetic interest in a building is to attend to it in all its completeness, to see it, not in terms of narrow or predetermined functions, but in terms of every visual significance that it will bear" (Scruton, R. 1979)

The following course descriptions outline how colour teaching is integrated in the curriculum at NTNU. This shows how the teaching of colour in architecture is extended from a theoretical component to crossing the implementation gap by emphasising colour as a material quality that engages in, and contributes to, the formal, structural, and aesthetic discourse in architectural and urban practice. The first colour teaching starts in the second semester (Architecture 2) and progresses with varying levels of interaction and into the master's level.

Architecture 2: Tectonic
In the second semester, students are introduced to the most important basic building materials and gain a basic understanding of architecture's most important design principles as well as experience of how architecture affects place and how a place influences the architecture. Colour is introduced as one of the key aspects of identity of place (Angelo, K. and Booker, A., 2018) on their first excursion abroad, i.e., Vienna and Graz. Students are given an assignment of studying the nominal and perceived colours (Fridell Anter, K. 2000) of buildings, when learning how to measure specific building facades.

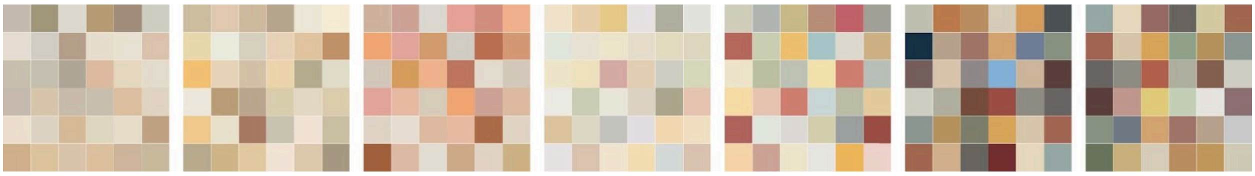

Figure 1: Examples of colour spaces of different European cities; Paris, Florence, Rome, Vienna, Graz, Copenhagen, and Trondheim.

Architecture 3: Housing
The third semester focuses on architectural design for urban housing, the basic typologies and organisational principles, dimensioning of architectural elements and space, light, construction and form in relation to the urban fabric, outdoor spaces and facades. This course runs parallel to the *Form and Colour, module 1.*

Form and Colour, module 1 start with an introduction to perception, light and colour and how colour can be used to enhance or conceal form. As all building materials have colours, inherent or applied, students are given examples of how colours affect the formal aspect of existing buildings, discussing how architects can use colour as an aid in the visual tectonic appearance (Ostwald, W. 1969).

Colour theory cannons, such as Goethe and Itten, and relevant colour reference systems used in the architectural profession (NCS and RAL) are addressed on the basis of their strengths and weaknesses, with the goal of extracting viable, practical advice. The aim is to introduce basic concepts of colour and relevant terminology to create a common platform for comparative experimentation and discussion.

The colour education is structured to have relevant transfer and implementation value to architectural practice across all building scales and locations. At first emphasis is placed on the key aspects of human colour vision; light, object/surface, and perception. Students are given an introductory assignment of exploring the elementary colours through painting and arranging colour samples according to their main visual character of whiteness, blackness, yellowness, redness, blueness and greenness. This is the core of the natural colour system (NCS)

Concepts addressed: colour reference systems in practice, colour properties and characteristics, lightness, darkness, chromaticity.

Assignment A) Colour and form
Students focus on composition with colour and are given a specific 2D composition with the task of making three visually balanced compositions, working with achromatic colours, equiluminant colours and complementary colours to explore the optical quality and its impact on the formal composition.

Concepts addressed: simultaneous contrast, advancing and receding colours, quality, quantity, proportion, balance, orientation, gestalt principles of colour.

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Assignment B) Colour and light
Students are given one colour with the task of designing a composition with nine variations of surface structure with the aim of generating a variance of perceived colour that is as wide as possible through use of texture, relief, and light reflectance properties.

Concepts addressed: structure, texture, relief, the spectral properties of daylight and artificial light, light temperature, light reflection, light dispersion, light, and shadow.

Assignment C) Colour and space
Students are given a specific 3D scale model with the task of making a spatial composition that is visually balanced when seen in all directions. The starting point is the colour palette from one of the 2D-compositions from assignment A, by experimenting in smaller sketch models before painting the final proposal.

Concepts addressed: simultaneous and successive contrast, spatial aspects of colour, advancing and receding colours, colour perspective, aerial perspective, visual boundaries, zoning, overall gestalt.

Impact on Architecture 3
Students begin to have a deeper appreciation of colour and material as an architectural design tool and are starting to understand colour's capacity in proportional and spatial articulation. Through a more methodological application in projects, they are starting to evolve more sophisticated arguments for material and colour choices in dialogue with context and the production of urban identity.

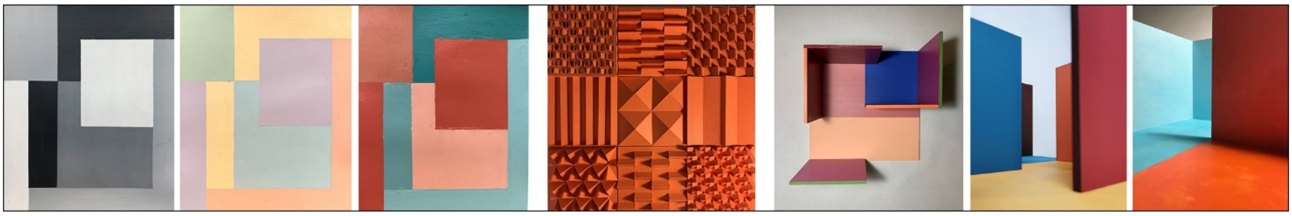

Figure 2: Example from Form and Colour, module 1, assignment A, B and C.

Architecture 4: Transformation
The examination and analysis of existing buildings through hands-on investigation. Developing projects on the basis of field investigation in conservation, reuse, and transformative adaptation with relevant choices of change based on careful attention to resource use and sustainability. This course runs parallel with Form and Colour module 2 which focuses on working within a specific colour pallet of a place and pattern formation from 2d to 3d.

Form and Colour module 2 further develop the understanding of how to implement colour in architectural practice through exploring the development of colour, material, gestalt, and the understanding of pattern structure in facade design; facades are composed of elements that result in an overall gestalt.

Assignment D) The Trondheim Palette
Students make their own "Trondheim palette" by mixing colours, selecting colour samples to represent the wider range within the colour space of the city. For this assignment, they have access to NCS tools (Indexes, atlases and colour pins) as colour reference for comparison. Their selection should represent the width and depth of the colours hues and nuances of the city.

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Concepts addressed: colour and context, colour and place, colour guidelines, colour reference systems, colour in practice, Norwegian standard for colour reference (NCS).

Assignment E) Colour, form and pattern structure - 2D
The students are given a specific "module" and tasked to experiment in creating different patterns by repetition vertically, horisontally, around the axis, by displacement, mirroring, etc. They first start in black and white and then introduce colour to their achromatic designs to explore the theme further and to experience how colour can visually change the perception of form and pattern structure.

Assignment F) Colour, form and pattern structure - 3D
Students develop a 3D-module out of the 2D-module and use the surfaces of the 3D-element to experiment with colour and how it affects form, and then make compositions based on repetitions of nine of these identically coloured elements/modules. The final task is either to make three different compositions where the element has the same colours but placed differently or use the same model composition making different compositions through three different colour schemes.

Concepts addressed: one element/module in repetition, format, rhythm, direction, orientation, size, scale, open, closed, positive, negative, facade design, overall gestalt, visual tectonics of colour.

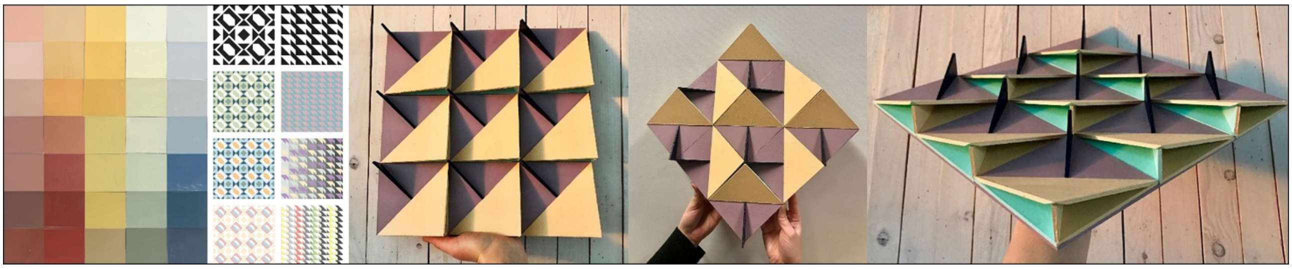

Figure 3: Example from Form and Colour, module 1, assignment D, E and F.

Impact on Architecture 4 - Traditional Colour Practice in Norway.
Students implement the acquired understanding directly in the semester's main project, and there is a sustained discourse on colour and material in heritage identity and adaptation throughout the semester. The Trondheim colour palette is used in all design projects, and plug-in colour assignments are set in the area the students are working in, with the task of experimenting with the effect of colours have on visual tectonics of the façade; advancing and receding colours and how active and passive the building elements are perceived in the overall gestalt of the façade (Fig. 4). Traditions in previous architectural styles and an understanding of the evolution of material in both heritage and more modern structures are also encountered. This develops increased appreciation for the craft aspect of colour and colours cultural role in heritage and epoch identity.

Concepts addressed: visual tectonics, formal aspects of colour, advancing and receding colours, perception of gravity in optical weighting.

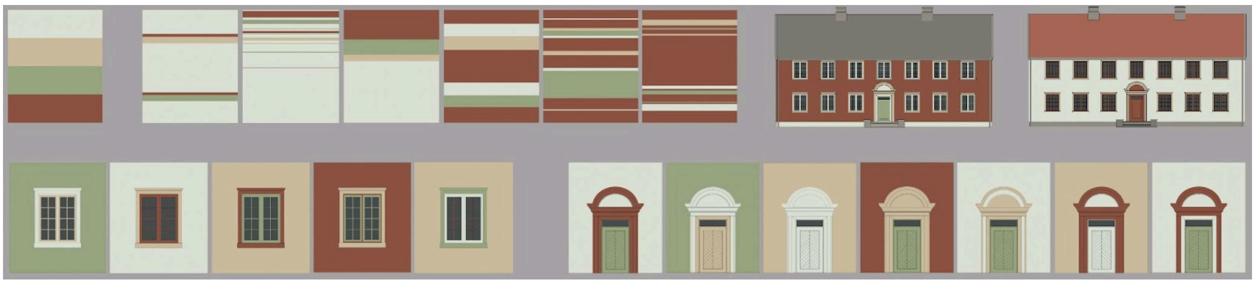

Figure 4: Example of assignment on visual tectonics of colour.

Architecture 5: City and Town Planning
developing sustainable conceptual urban design proposals and urban planning strategies including a general understanding in sustainability and ecology. Methods for analysis and design of urban settings and landscapes space, form/ typologies, and functions. Input on the history and contemporary practice in urban colour plans with particular emphasis on identity, ambience and wayfinding, extended discussion on the importance of climate, solar angle, geographic position and locality in colour and material perception.

Architecture 6: Large Buildings
The course develops the knowledge for designing large, sustainable buildings. The course focuses on situational analysis and awareness, application of given context, program, functionality, concept and expression, the structure and elements of buildings, regulations and safety, construction principles, and technical infrastructure. The form and colour component are substantial with extended discussion of gestalt structure in relation to colour and materials in facade and body form and its impact on, and relation to, urban and regional identities and the objects communication in relation to publicness and everyday aesthetics. Students are encouraged to think with colour and material as a contextual and idea generating tool from the first conceptualisation stage. This is maintained throughout the course by the availability of colour expertise for student project teams. It is expected that students show both colour and material implementation in their final presentation

Figure 5: Example of project on Architecture 6: Large building, where knowledge from Form and Colour is implemented in façade design.

Summary of colour teaching at BA level
At the conclusion of their first six semesters (BA level) all students have encountered colour in multiple contexts and through this have developed an understanding of colour's role and relevance in architectural and urban design, at each stage the potentials of implementation have as far as possible been brought from theory into practice. A significant number of students continue to develop their interest at master's level.

Tectonics in architecture is defined as "the science or art of construction, both in relation to use and artistic design". It refers not just to the "activity of making the materially requisite construction that answers certain needs, but rather to the activity that raises this construction to an art form." (Maulden, R., 1986)

Master Design Course: Architectural Design with Light and Colour
Architectural design with Light and Colours is a design course with a specific focus on the perception and practice of light and colour in an architectural context, and the course is taken parallel with the theory course *Light and Lighting*. The theory course focuses on daylight in buildings, both quantitatively and qualitatively, and the knowledge is used in the design course when designing the final infill project. The use of daylight in the final assignment on the design course is not discussed in this paper.

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The design course has particular focus on application of natural light, building materials and colours in architectural design. The course builds on colour teaching at BA level and aims to further develop practice-related design skills in colour design in public spaces. It focuses on exteriors in the urban realm and universal design in interiors, building up aesthetic argumentation and at the same time complying with building regulations and requirements for public spaces. The specific sites for the design projects changes as the course co-operates with municipalities in different towns and cities in Norway, and with various partners in the paint, render and cladding industries (Fig. 6). The aim of the course is to apply learned concepts, methodology and terminology to argue functional and aesthetical aspects of architecture in an urban context.

Figure 6: Example of exercises on the master design course with real clients in making new colour selection for linseed oil paint for a company in Oslo, interior palette for client with focus on universal design and LRV, and façade colour palette for new building block in a specific area of Trondheim.

The design projects aim to reflect and respond to contemporary architectural challenges, i.e., identity of place, urban densification, infill projects or building rehabilitation in a specific overall gestalt of a site/street/area/city. The Norwegian Directorate for Cultural Heritage (Riksantikvaren) declared in 2017 a change from the earlier strategy of *contrast* between old and new to emphasis on *dialogue* between the old and new, e.g., dialogue between building materials, overall gestalt of pattern structure, typology and colours. However, the question of *what is a good dialogue* between existing buildings and new additions is not particularly well exemplified or specified. To achieve this good dialogue the knowledge developed at BA level in colour and form, pattern structure, relief, material colour, building elements and sequential structural order and context are essential.

The final design project starts with on-site registrations, e.g., light, natural context, building materials and typologies, colours, building pattern structures, how the area is used and what functions are there, to identify the *status quo* of the dialogue. Counter to most current practice of approaching the project from the inside and out by starting with a programme – students instead respond to the site as to what would be a good function of a building in the area and what would be a good aesthetic addition to the context, i.e., from the outside and in. The aim is to establish the functional and aesthetic "frame" of the context at the beginning rather than as an adaptation at the end of a project, and that all choices of building materials, colours and visual tectonics, respond to the overall gestalt of a specific place. Students are encouraged to respond and explore by inclination and ability but are required to professionally argue all of their choices, both for building design and its relation to the context.

Concepts addressed: context registrations, visual tectonics, pattern structures, dialogue between old and new, identity of place, dogmas of contemporary practice, urban hierarchy.

Figure 7: Example of registrations of colours, materials and overall gestalt for the final design project.

Figure 8: Example of student projects and studies of brick and mortar colours, and of the variation of facade elevation model in 3D of several student projects.

Diploma level

At the masters (M.A.) and the Diploma (final examination) level we see students who chose to specialise on architectural colour and an increased number of students who address colour as an important design factor and actively seek further consultation on colour issues. Indirectly: an increased number of graduates move into practice as architects or consultants that actively address colour as an important architectural and urban design factor or have been engaged on the basis of their demonstrated colour competence.

Conclusions

We conclude from our experience that a meaningful re-weaving of colour into architectural design is dependent on colour teaching that has direct and transferable value in supporting continual semantic development and practical implementation at every stage in the student's trajectory towards professional practice.

Gestalt, colour and tectonics are treated as descriptive and discursive rather than as exclusively explanatory in nature, the integration of their principles provide part of the semantic vocabulary that allow students to grasp and discuss compositional propositions, it is understood as a form of analysis describing perceivable tendencies in visual organisation, as such it provides the students with a set of tools for analysing, understanding, and manipulating the cumulative qualities of elements and objects in a coherent way in the visual field and in three-dimensional space. The tendencies of colour and tectonics are understood as a set of qualities that interact to variable degrees at any given time, and that they may be manipulated to generate hierarchies of proportion, position and balance, dynamics of rhythm, order, flow, and variation. An understanding of these combined gestalt tendencies equips the students with a set of actions and understandings that enable a deeper structural discourse on the dynamics of composition at a formal level (how elements work together) towards a more complex emergent function in visual, spatial, and structural rhetoric and contextual cultural implications.

Sustaining discourse on colour throughout the study with input that is relevant produces results that are visible both in the quality of the individual work and in understanding of the function and purpose of colour in an aesthetics of structure, furthermore, graduating students have the grammar and experience to confidently explain and argue for their decisions with a rational, formal, architectural and contextual language that goes beyond a purely subjective, expressive feeling and is more firmly anchored in a relational understanding.

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The Face of Molde High Street

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Abstract

Research conducted in connection with the restoration of architectural polychromy in Norwegian cities rebuilt after the 2. World War. Focus on the identification of historic facade colours in the Main Street of Molde and the translation of these to modern technologies and materials.

The Main Street, with its tight composition and clearly defined building volumes and urban spaces, forms the core of the reconstruction of Molde. It was planned by architect and professor Sverre Pedersen in the late 1930s, and a revised version was quickly adopted by "Burnt Cities Regulation" after the bombing of Molde in 1940. The modern street was built with sober plastered volumes painted in rich traditional hues. Quite a few of the facades also had mineralite plaster. The street is now listed as a protected zone by the Norwegian Directorate for Cultural Heritage

Over the years, many of the buildings have acquired seemingly random, and sometimes unfortunate, gloomy colours and surface structures.

In 2017 the Municipality decided to raise the quality and uniqueness of the centre of Molde. One of the initiatives was to produce a colour plan for the High Street, based on the uncovering of original colours from the reconstruction period.

In this paper we describe the process of working with this plan, the method and the result. We discuss how to transform the historic findings into appropriate paints or coloured plasters, without having to match them to standardized colour notation systems as a reference for the houseowners. This method is common, but represses information and reduces and disembodies colour as material. (Trauwein 2012). More attention is required to this face of colour restoration work, in order to fully understand and transform historical palettes in a more authentic way.

Keywords: Colour plan, Restoration, Historical Polychromy, Pigments, Binders, Transformation, Communication.

Introduction

In Norway there is an increasing interest and an awakening towards more colour in architecture and design. This is reflected in more vivid interiors and a gradual transformation of grey and neutral facades to more friendly and humanistic colour schemes.
In the wake of this, quite a few Municipalities are interested in a stronger colour management of existing and future architecture in their regions. This can be concrete colour plans for specific streets with detailed specifications, or more general guides for townscapes and developments. The City of Oslo Planning and Building Services is currently preparing a colour guide for the Capital, which of course has a strong synergy effect on other planning authorities and agents in the country.
We welcome this engagement as part of urban strategies, but we want to direct some attention to the actual execution of colours at the other end of the planning process. What is considered important is not only to convey colour as a visual, aesthetic phenomenon, but also as material (and light), especially in the realm of the cultural history of colour. The tradition for colour planning is fairly new in the post-war Norway, hence Municipalities and other agents who are engaged have little or no experience in how to best describe and help houseowners through the process with entrepreneurs

or craftsmen. Not enough thought and precision has been put into this endeavour, the actual materialization of colours, whether they are new or historic.
We address this problem through a type of colour plan which is increasing in those parts of Norway that was bombed during the Last World War. These are plans that are mostly based on the reconstruction of historic hues for towns, streets or places from the period 1940-1960.
Obviously colour as an integrated part of architecture and urban strategies was more common before and during the last World War, and the realization was easier because there were more direct ties to craftsmen/painters. Through this project it has become clear how this tie is broken by the industrialization of colour, and the lack of skills and knowledge in traditional crafts related to colour in architecture.

Colour for rebuilt cities

Townscapes that were extinguished at the beginning of the Second World War were rebuilt rather quickly during the period 1940-45.
"Burnt towns regulation" (Brente steders regulering) was the Norwegian public agency that was responsible for the preparation of planning for all places, cities and towns in Norway that were affected by the bombing. Professor of architecture, Sverre Pedersen, was the head of the project at the expense of the state from 1940 until he was replaced by Erik Rolfsen in 1945.
Each city and town, a total of 27 in number, got its own local office with a specific group of Norwegian architects to work on zoning plans. The work continued after the war and especially with the rebuilding of Nord-Troms and Finnmark after the destruction in 1944.
(Store Norske Leksikon: Brente steders regulering)
There was an unique understanding that the simple and rather straight forward architecture that was raised, needed colouring as a humanizing factor in a difficult war situation. An extreme example is the town Kristiansund on the west coast. Here 2/3 of the city centre, containing mostly wooden architecture, was bombed and rebuild in such bright colours that it was named "The Polychromatic City". It even received a more condescending mention,"The Paintbox", from chromophobic agencies, and over the years most of the houses here, as well as in other rebuilt cities, were painted in more neutral colours.
Today municipalities realize that losing colours means losing identity as well as urban quality, and actions are taken to recover the lost hues. The search for the original documents is going on, but again, documents and plans are not enough. The best answers are to be found in the buildings themselves, as long as the materiality is original and appropriate methods are used to obtain the correct historic layers.

The Face of Molde High Street

The centre of Molde is one of Norway's best-preserved towns rebuilt after the War. The facades of the Main Street, and the city centre in general, form the walls of perhaps the city's most important urban space. The simple building volumes were raised mostly with three floors and slate roofs. Some buildings, which were strategically placed to mark portals, often had a fourth floor. Although the volumes were simple, there was much exclusivity in the buildings' details. There was usually wood (teak) in the doors and window frames. Canopies were originally minimalistic in design with copper fittings. The balconies had simple wrought iron ornaments. There was also a wealth of detail in the mineralite plaster which covered a large proportion of the buildings.

There was never any well planned polychromy for the restoration work in Molde, and it took some time before all the buildings were painted, apart from those that already had different shades of mineralite plasters. But we know that the city around 1960-70 was far more colourful than it was at the beginning of 2017, when The Municipality started to promote a new understanding of the urban quality of the reconstructed city. The idea was that a conscious attitude towards these values, amongst that the historic hues, would create predictability and a valuable discussion in further urban development. It would hopefully also convince the houseowners to get rid of the drab neutrals. The beautiful plan developed by Sverre Pedersen during the war deserved to be celebrated with all possible aesthetic tools.

A colour strategy for High Street and a few adjacent small streets was thus initiated. The Municipality gathered professional and artistic expertise in colour practice and theory as well as conservation work. The project was led by the Planning and Development Department by architect Lone Kjersheim and was a collaboration with the Building Conservation Department in Møre and Romsdal County by Christ Allan Sylthe and Toril Moltubakk, as well as experts from the Norwegian Directorate for Cultural Heritage. These two institutions also contributed financially, together with other minor entities.

The main work was performed during the period 2017-18. The actual palette was developed by the authors of this paper, artist Bent Erik Myrvoll and artist/architect and professor of colour Mette L´orange, in close collaboration with the above representatives.

The project was based on a cultural-historical analysis. Uncovering facade layers in most of the buildings gave an unique platform for both restoring and developing the architectural polychromy of the street. Budget restrictions or other reasons prevented taking samples from all the historic facades, but colour charts from the actual period 1940-1960 were valuable complimentary tools. The results of the analysis was matched against texts and images from the post-war years (though hand coloured), as well as paintings by local artists, more as an inspiration than as verification.

Method

Quite a few of the authentic pigments and binders was secured in the process. Different "excavation methods" can lead to success, the approach for the work with Molde High Street is described here and has been regarded as thorough and competent.

The first step of collecting information, was to map existing hues and materials along the facades. This was mostly done according to the NCS Colour Notation System (https://ncscolour.com/), and was a way of getting an idea of the current chromatic picture, especially the original mineralite. The material layers of most of the facades were then revealed by using a diamond core drill with a diameter of 3 cm, which extracted core boron samples. These gave large enough samples of the plasters- and pain layers to be able to determine the original pigment bases and materials used.

The core boron samples were supplemented with larger studies of the mineralite on the actual surface of the buildings. The extensive scope of the performed research revealed with a high degree of security the pigment and binders used.
These samples were photographed with a Hasselblad Hd3 50mgp CCD and the Hasselblad x1-d 50mgp CMOS with a HC 120mm 4 macro lens with intermediate rings. This is a camera with very high resolution. The photos were transferred to a large screen which enabled the multidisciplinary work team to study the results together and enabled a close collaboration and understanding. These photos with high resolution were also used when deciding the thickness, composition and content of the mineralite plasters.

Hasselblad was preferred instead of other equipment such as microscopes, partly due to its light weight and effective usage. When zooming with a Hasselblad-camera, pigment granules are seen at a level of detail that is almost only provided by microscopes.

The camera delivers 16-bit colour files, which is a multiplication of the colour information in each channel provided by more conventional cameras. The Hasselblad's medium format was used in the photographing of the facades of High Street to make a photocollage as a working tool. The same camera and optics are thus used in all operations. This is beneficial, as the information on each colour and its different layers are directly seen in the macro photo.

Simple chemical analysis was also done, as an extra verification of the pigment and binder compositions of the samples. Small batches of the paint were produced with these compositions to obtain the most likely original hues. The same hues were transferred with water colour onto a large drawing of Molde High Street. Wherever historic samples had been impossible to obtain, traditional colour charts provided hues that were typical for the actual period.
As a supplement to the small samples and the large hand painted drawing, larger lime plaster samples were made on stone, as well as samples of several mineralites. These two actions were made possible through the authors broad artistic competence in mixing colour and experience with lime based work. The work was produced in Bent Erik Myrvolls artist studio in the neighbouring town Ålesund, which has all the necessary equipment and a large pigment resource. He has gathered pigments over the last 30 years, amongst that historic pigments like those used in Molde in the period 1940-1960, and has also the binders available.

Fig. 1 Core boron samples and macro photo. Paints, plasters and mineralites.

Process

Despite the intention of finding new ways of reproducing the historic paint and mineralite, the painted samples were, as an experiment, matched with NCS codes in order to digitalize a version as a working tool, only to facilitate a digital communication within the working group. Each hue was represented with alternative nuances around the same hue, a "colour space" to give room for adjustments. The project group was aware that this type of disembodiment of colour would reduce the quality of the work temporarily. However with so many parts involved it was the best way of exchanging opinions at the sketch level. The existing colours were also digitalized and complimented the findings.
An important discussion at this point was between the Conservation Department in Møre and Romsdal County Municipality and the rest of the project group as to whether the original colours

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were to be used consequently regardless of the aesthetic value and contribution to the whole scheme.
The Municipality decided that there should be an estimation in each case, adjustments within the colour space was accepted and in some cases existing colours could be kept. They made clear that the authentic hues were a source of inspiration and a foundation for the colour plan, but not a dictation.
As part of the process information meetings were held for houseowners and other interested, and in 2017 the Municipality arranged an exhibition of the work in progress as part of Moldes 275 years city jubilee. The project group made sure to show most of the retrieved historic colours and mineralite plasters as actual material samples. The large watercolour painting was presented on the wall together with street views in colour as well as historic photos. A print of the painted streetscape was displayed on a table for people to comment on the work, write important historic knowledge about the buildings, colour changes through time etc. City walks and lectures on colour and material became valuable events both for the citizens of Molde and the project group.
This also made the dialog with the houseowners much easier.

Fig. 2 Production of material samples for "Work in progress exhibition". Water colour renderings and lime based test plates from historic findings.

Result and discussion
The final palette for facades was launched in 2018. It combined earth colours in darker and lighter tones, with some more saturated hues, in a balanced street composition.
The Municipality wanted the palette to be a framework for a colourful and exciting streetscape that would stand the test of time, based on the history, with a foot in the future.
It was not a goal in itself to restore everything, but the result shows a high degree of authentic colours. Of the 105 housing estates included, 80 have been given colours with references to historic findings in drill samples, photographs or paintings. 15 buildings have been given supplementary colours to create exciting features and harmony, while 10 buildings are kept as they are. Buildings that have been completely rebuilt, or that have been added more recently, are not included in the plan, also to provide room for alternative and modern features in the cityscape.

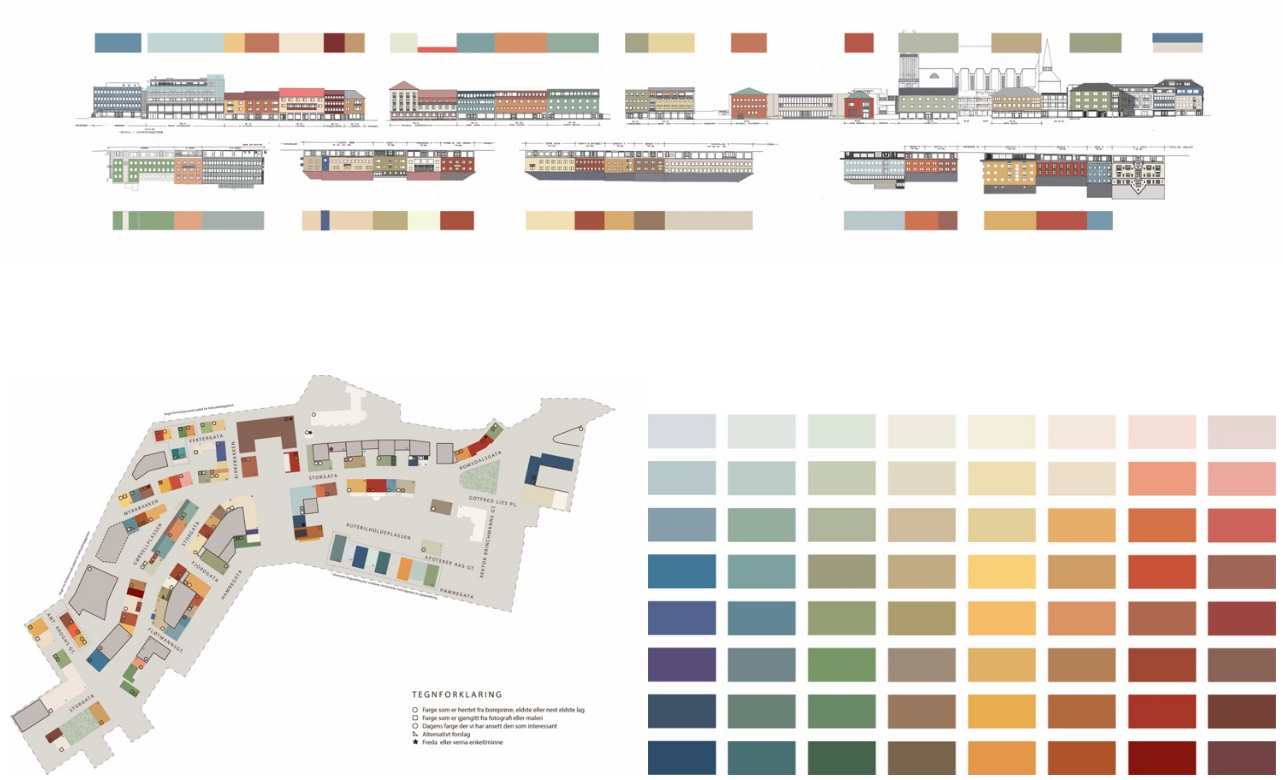

Fig. 3 Final colour plan, street scape and palette. Without colour coding.

For the nine wooden houses included in the plan the palette for Kristiansund´s architecture reconstructed in the same period, as mentioned above, has been a resource.
The total plan has been composed with a certain regard to views and sections of city spaces and quarters.

The translation into NCS colour notation system for digitalization was an intermediate stage for visual play with the street composition, and was later withdrawn to avoid a production hues with a mixture of unspecified modern pigments common in industrial paints. They would maybe look similar to the historic colours, but would lack original material content and most certainly not the brilliance
and duration of the old mineral pigments.

The final result was therefore presented as a digital pdf for the public without any coding, awaiting an alternative solution for the material execution of the colours.

A physical demonstrations was held for the houseowners to inspire them to reconstruct or repair the mineralite plasters. Lime plaster and mineral pigments were used, as well as marble stone from the nearby area of Eide, showing how unexpectedly beautiful this materiality is because of the high degree of light reflection in the particles of such a surface.

The mineralite test plates were made in 50cm x 50cm in order to hold them up against the facades. A selection with coloured plaster surfaces and real silicate paint was also made available in order to communicate a wide range of calcareous pigments in more simple plasters.

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Finally a pilot study was launched to make further research into alternative possibilities of materialization. Three properties were chosen for this exclusive handling. One example was Vektergata 5, a wooden house with a mineralite first floor. A funding made it possible to produce original recipes for both the paint and the mineralite.

For the reconstruction of the mineralite, a report was drawn up with thorough analyses of the mineral content. A yellowish and vibrant ochre pigment was to give the main colour of the plaster. The report and specific order was sent to a mortar factory in Denmark, through an agent in Bergen, as there are no such manufacturers in Norway. Hence there were many agents involved and some information about the pigment got lost in the communication. The possibility to check test batches physically was not there. The plaster that was delivered subsequently lacked the yellow tint of beautiful ochre that was ordered and had too many black stone particles in the surface. This made the mineralite look more beige than yellow.

Another pilot study, Strandgaten 5 and 7, was a very successful project. A lime plaster was made and thereafter painted with silicate paint. Here the project group had full control of the recipes and the process.

Possibilities for making specific "historic recipes" for some houseowners in the pilot study was beneficial, although the pigment base was misinterpreted by the mineralite producer. For the whole project plan this was out of scope. The working group therefor to enter a direct cooperation with a producer of silicate paint and plasters, who could offer durable colours and system solutions for the facades on a pure mineral basis. The colours had to be rematched to their assortment, some could be made specifically, but better to obtain the quality of material as long as the colours are as near to the reconstructed values as possible. Historic accuracy of colour is an illusion anyway, this became the best material solution for the rest of the houseowners.

Fig. 4 Pilot project 1. Yellow Mineralite reproduction in Colour Lab. Test pieces made according to the core boron test from site and the macro photo. Background: Final result lacking the brilliant yellow ochre pigment.

Fig.5. Pilot Project 2

Conclusion

The project had an ambitious starting point with a focus on colour as material and light. Hand painted samples, presentations in watercolour, actual mineralite plaster samples were made in the studio and demonstrated for the public. The authors took advantage of diverse backgrounds, which includes several years of experience from working as artists, architect and conservator. This advantageous combination of competence enabled better assessments and decisions regarding the historic findings and how to use them.
In the cases of single objects in this study it was possible to have a special concern and provide necessary materials for a near to authentic reproduction of paint and simple plasters. It however became obvious that mineralite reconstruction requires closer attention to the production phase than the one we were able to provide. The enhancement of smaller local producers who can be hands on these interesting challenges are thus welcomed in the future.

The problem posed of materialization will be discussed further and is a problem that concerns many actors in the work of restoring and reconstructing colours. We chose one solution, far from ideal, but we considered it close enough to the original material and hue composition.
Few of the actors working with colour plans have the possibilities to work in a colour lab like the above mentioned with pigments and binders. Hence they are being far away from a material approach, nearer to a digital one, which, alas, often leads to superficial solutions.
To be debated.

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Colours of a Northern city in past and present - tradition and current practices of facade colour in the historical architecture of Trondheim, Norwayt

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Abstract
The city of Trondheim today has remnants of buildings from most decades of its thousand-year history. Of the medieval city structure only monumental stone architecture and archaeological material has survived, whereas the city's traditional wooden vernacular from the 17th century and onwards still lines the streets and constitutes much of the city's image and character. In the fabric of historic facades, as well in the display of both old and new architecture there is also a rich color history, characterized by warm pigments set against the cold northern light, with variation in composition and enhancement of architectural detail. A current tendency is that international trends in color and house painting are challenging what is considered typical and traditional color schemes. Today both historic and new wooden buildings are increasingly painted white or grey, or clad with wood which is untreated or treated with other remedies than paint. In considering the historical city and what is perceived as traditional coloring of buildings, and new trends in building which affect the image of the city, raises questions both concerning our knowledge and our actions in relation to colors in historic architecture, preservation and the urban environment. Is the color tradition of Trondheims buildings what we see, or do color excavations reveal a different historical approach to historical color scheming of houses than what is visible today? What are the specifics of painting the wooden vernacular, before and now, and why do fo few use traditional paints on traditional buildings? And is there a specific «Trondheim palette» to painting buildings which can be locally defined? This paper will explore the color history of Trondheims buildings in its regional and national context, and discuss some of the measures taken to maintain a historical color tradition, and preserve the city's historical colors as well as its historical buildings.

Keywords: architecture, color and restoration, enhancement of cultural heritage.

Introduction

The city of Trondheim is Norways third largest city. Today an urban sprawl of 250 000 inhabitants, its historic city centre housed around 5000 people in the late 18th century. This time reference is relevant in our context, as little of the city´s historic architecture and vernacular predates the late 18th century. The main building material since medieval times was wood, and the city has succumbed to fires and subsequently rebuilt numerous times. With this, there has been a continuous renewal of the urban fabric. The single largest fire in the city´s history was the so-called "Hornemann" fire in 1681, named after the merchant Hornemann in whose warehouse the fire started and spread, leaving the whole city in ashes. A new town plan was ordained by the king and the city rebuilt according to a baroque city plan with a rectangular grid of broad streets cutting across the dense medieval structures of narrow lanes. Most buildings were erected according to tradition with timber structures, developing in form with facades displaying new ideals in architecture. Only a few monumental buildings were built in stone or brick, this being a much more costly building material. The 18th century is referred to as Trondheims "golden age". Trade was thriving and merchants dealing with copper, timber and fish accumulated wealth. The new urban spaces of the baroque plan gave a new opportunity to display wealth and standing. Along the broader streets and new large town square the wealthier citizens built housing and larger palées. By this time cladding was becoming more common and with this, paints and colour on a broader scale was introduced. The architect and painter Arne E. Holm, professor at Trondheims Technical University (NTH) made studies of Trondheims colour history. In a series of articles published in the early 1980s he discusses his sources and findings. Among the sources used from the 17th, 18th and early 19th centuries are drawings, maps and paintings. Holm comments a city prospect from 1813 in the following way: “The red painted churches and the Sugar House stand out. As do the ochre colored palées, Stiftsgården and Harmonien. These have black roofing. Most houses at this time have white walls and red roof tiles.” (Holm, 1983) (Fig. 1).

Fig. 1 – Prospect of Trondheim by M.F. Dalager 1813
(Trøndelag Folkemuseum)

Perspectives on the colour history of Trondheim architecture

The buildings Holm refer to are buildings monumental to the city at this time: two wooden early 18th century churches, Hospitalskirken and Bakke church two of the oldest standing wooden buildings, both timber structures with vertical spruce cladding painted red, Sukkerhuset, a large building which was originally a sugar refinery, later brewery, characterized by a tall whitewashed brick and a timbered upper storey clad and painted red, and two of the paleés near the main square, Stiftsgården and Harmonien, which at the time were painted a light ochre. By the 1840s the palées lining the main streets and town square had been painted grey and white. (Holm 1983; Holm 1985) Holm refers to ochres and reds as traditional, whites greys and blues as fashionable. He also ascribes colour use to class and standing. Expensive pigments and binders were introduced by the wealthiest, followed by those who could afford it.

The development of wooden architecture in Norway towards a more colourful exterior is a common feature which can be linked to the technological development of the saw. Plank cladding or paneling of the exterior became more common during the 18th century, after the introduction of the water-driven saw, and with this the use of paint in the exterior also gradually became more common. This new custom began in the cities and along the coast, while inland it took longer for paint to be taken into common use. With the high quality of wooden building materials at the time, paint was applied equally for aesthetic reasons as for its protective properties. (Aanensen et.al., 1980)

In Trondheim, the city that burned in 1681 consisted of timbered buildings with bark and grass thatched roofing, and walls partly cladd and treated with tar, according to contemporary written sources. However, ochre and erde (red earth paint) had been imported to the city throughout the 16th century which indicates that some colour was present in the city image also before the massive fire. Witness statements from the fire refer to at least two houses were painted, one of them red. (Holm, 1983). In the early and mid 18th century, reds and ochres were typical for monumental buildings like churches. By the 1780s dark ochres and reds were becoming unfashionable. Housing taxation protocols from a fire in december 1788 describe, among other characteristics, the colours on the burned buildings. In the quarter that burned there was red and ochre as well as beige, white, grey and blue. (Holm, 1985) A significant factor for the lesser status of reds and dark ochres was the price. These paints were based on local pigments and could be produced with inexpensive binders such as rye and cod liver oil. By the time Dalager painted the Trondheim prospect in 1813, the more expensive white pigment had become more fashionable, and for those who could afford it facades were painted in white, beiges and pearl greys, or lighter ochres and reds with white lin seed oil paint mixed into them.

Pigments and binders

In the Nordic countries there is documentation of treatment of the surfaces of buildings and boats predating medeival times and tar kilns dating back to roman times are found in a widespread geographical area. (Riisbøl et.al., 2021). Norwegian stave churches were treated with tar, a tradition which is upheld today. For Trondheim, no wooden medieval standing structures have been preserved. The medieval city has been largely reconstructed on paper on the basis of findings from numerous archeaological excavations, the surface treatment. Tar does not shield the building from rain as tar, even in thick layers, allows moisture to travel freely between air and wood. To wood, the sun is an agent of deterioration, as is water and tar primarily protects the wood from damaging light. The sunscreen effect and the diffusion-open shield which allows the wood to dry out properly after rain, makes tar an efficient surface treatment for wood. The resins in tar also contribute to its protective proterties. Treatment of exterior surfaces on vernacular wooden buildings in Norway before the 18th century was seldom with pigments. Kiln-burn tar was to some extent used, as the account from Trondheim after the fire in 1681 tells us.

A strong tradition in Sweden and common also in Norway, although here not so much for notched timber buildings as for clad buildings, is paint based on rye as a binder. The function of the paint is, like tar, primarily a sun-screen. Containing no fats or resins, it does not infuse the wood and prevent the uptake of moisture, but it also does not prevent moisture from evaporating. Ingredients for rye paint were available to most, and the cost of materials low. In Norway this paint was found in cities in the 16th and 17th centuries, and frequently on those parts of the buildings which were not exposed to the public. (Aanensen et.al., 1980). Red rye paint continued to be a common paint for barns and utilities buildings throughout the 19th century and accounts for the numerous red barns across the Norwegian countryside, although today the binders are synthetic oils or plastics.

Linseed oil was the common binder and the more expensive. Along the coast, cod liver oil was commonly used as a binder for paint. It has excellent qualities for wood protection, its drawbacks being an eternally sticky surface, and an always, however faint, liver smell.

White pigments came into use for buildings of all styles when the less expensive sink pigment replaced led in the 1850s. At this time the coastal towns of Norway, which were quicker to pick up on trends due to much contact with the continent because of shipping, became white, as were eventually also the originally darkly colored swiss style buildings.

Natural stone buildings were also treated in Norway. Lime protects stone buildings from weathering, while at the same time allowing for transportation of moisture in the structure. Restoration works have also here left stone structures exposed after restoration, which were originally covered with lime mortar and lime wash, an example of this is Trondheim´s church of our lady which today has exposed stone walls, but which was originally lime-washed and white.

Shape and style

Trondheim´s prominent Latin school, Trondheim Katedralskole, built in the 1770s and attributed to the Danish architect Harsdorff, was built in red, narrow brick with white contrasting window details and a darker color main entrance door. Traces of red and white pigment have been found on the façade, proving that the building upon completion was rendered in red paint, the mortar grid marked with white. The color treatment enhanced the color and effect of the original material. (Holm, 1985)

Fig. 2 – Munkegata in 1810, the Cathedral School to the right. A. Schiølberg 1810.
Trondheim Municipal Archives

In Trondheim's most prominent late 18th century building in wood, Stiftsgården, the original color was ochre, with architectural detailing in warm gray umber. The buildings original ochre was a light ochre, ochre mixed with white, and although ochre was a traditional colour the bright tint must have been surprisingly new at the time. The buildings colour history is complex. Around 1800 the building was painted fashionably white, it was then painted light yellow, followed by a gray with traces of pink in the 1840s, then subsequently sevaral layers of gray before it was again painted white in 1906. The white building was firmly established as the identity of the building in the townscape. A larger restoration in 1958, when the second storey was refurbished as appartments for the Royal Family, included restoring the facade colour to it´s original light ochre. (Fig. 3) The change was controversial amongst the conservative general public. However, outrage was soon replaced by acceptance. The diversity of colours enhance the strong architectural features of the facade; negotiating the styles of rococco and neoclassisism, this is one of the country´s most prominent examples of 18th century architecture. (Holm 1983)

Neoclassicism had a large impact on Norwegian architecture and vernacular, frequently the style and colours of the original stone buildings of the south were translated to accomodate the wooden building traditions of the nort. In terms of colour, buildings were not coloured with the stark polychromes of the original Acropolis, which were unknown to most, but they were also not «marble white». In the Nordic countries, neoclassical "whites" were grey, green, yellow or pink. On wooden buildings the effect of stone could be achieved with adding a touch of red to the white for a pale pink, or white to ochre to achieve a sandstone; umber and white for a warm grey. Windows in neoclassical buildings were not always but frequently painted in dark colors, brown, black, grey or dark green, the idea being that the window frames thus became "invisible", from a distance merging visually with the glass, to give the illusion of a hole in the wall, which was the case of the windows of roman villas of antiquity and of the renaissance; holes in the wall open by day, closed with wooden shutters by night. The colours we find in late 18th and 19th century Trondheim correspond with the neoclassical style. The whites and grays and beige which were populare at the time were infused with pigments of green, ochre and reds. (Holm 1985)

Architectural detailing with neoclassical forms and mouldings, the play of light and shadow, combined with the slight contrasting colours and dark windows, adds to the complexity of the architectural expression. Simplified copies and pure white and gray does not do justice to the architectural quality of the initially simple buildings of Trondheim.

Fig. 3 – Stiftsgården. Hand coloured photograph 1915; photograph 1978
Trondheim Municipal Archives

In the 1950s and 60's modernism fell onto pre-war architecture, and many buildings which would or could have become historic landmarks, suffered with pragmatic modernization and the introduction of modern materials and form. This was also a fact for the historic centre of Trondheim.

A more recent example than Stiftsgården of a colour restoration is Arne E. Holm´s plan for the colour restoration of Munkegata preceding the city´s millenium jubilee in 1997. A series of letters between Holm and the municipal conservation office recount the strategy and field work preceding the restoration. The parade street of Trondheim consists of numerous privately owned buildings dating back to the late to mid 19th century, both rendered brich buildings and wooden buildings. Holms was in correspondence with all owners of buildings on the street, a vast task in itself, and performed colour excavations on all buildings with original surfaces. The colour scheme for Munkegata was based on a combination of findings for the individual buildings, but also took into account the harmony of the street as a whole. An example of a section of the street (Fig. 4) shows Holm´s introduction of pink, beige and green, which were traditional colours for Trondheim, advised to replace the beige and browns the building had aquired in the fashion of the 1970s. The building had suffered a loss of original architectural detail which the colour restoration sought to compensate.

Fig. 4 – From left: Munkegata 58-60 in 1870, in 1985; colour proposition 1981 by A.E. Holm; and in 2021.
(UBiT; Trondheim Municipal Archive; Holm 1981; photo MB 2021)

The restoration of Trondheims historic colours – scientific or strategic?

Is the restoration of Trondheims historic colours, as it has been practiced in the second half of the 20th century and up to our time scientific or strategic? Was it based on knowledge and scientific

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research into the buildings colour history, or has the use of colours on historic buildings been used to enhance and increase the status of old buildings, thus contributing to their acceptance and preservation?

In practice, both approaches have relevance. Arne E. Holm performed colour excavations on buildings with original cladding, discovering up to 15 layers of exterior paint on buildings from the early 18th century. However, he also acknowledges that very few buildings have original cladding and facade detailing to examine, as these have been replaced and renewed over time. For the palée of Stiftsgården, his colour proposal in 1958 was controversial and starkly opposed by a conservative general public. However, when the work was finished and the white had been replaced with the original ochre and warm gray the colour restoration, based on colour excavations on the original cladding and detailing, was embraced by the same public. In the colour scheme for Munkegata, he used both colour excavation and an aesthetic approach to compose a row of houses which demonstrated traditional colours to suit the buildings age and form, to form a harmonious whole.

The 20th century saw much use of color in the stylistic varieties of the decades. Except by a very small group of architects working in or close to heritage management, little heed was paid to historic architecture. Before 1980 the solution for many buildings was the color white or the trendy browns of the 60s and 70s.

The restoring of historical correct color to a townscape is a complex matter. When “excavations” of color layers on old color treated surfaces reveal layers of colors or décor, decisions must be made as to which layer is significant and correct for the building. Another matter to be considered, aside the correctness of the building, is the relation to other buildnings of the street or town section. In a dynamic and changing city, this is especially complex. Arne E. Holm’s color suggestions for the restorations of Munkegata are a good example of both. Examinations of buildings were performed, followed by discussions on probability, and relation to neighboring buildings, frequently newer. These color reconstructions, which were made in preparation for the towns millenial jubilee in 1997, significantly helped in restoring dignity and coherence to the town centre of Trondheim, which until a conservation plan was implemented in 1981 had undergone renewal with little sensitivity and respect for historical substance.

Holm and byantikvaren can take the honor for the town present variety of traditional colors, especially bryggene, Munkegata and the conservation areas of Bakklandet and Sanden, where a certain practice has been established. This work must however be continued. It only takes one change of owner to break good practice. Recent color reconstructions in Møllenberg re-introduce dark window frames, pinkish whites and warm umbras, the starting point of a positive color restoration practice for this area.

The Trondheim “palette”

In 2015 a colour registration was carried out in Trondheim by the municipal urban planning office, on two central historic streets in the city centre, the row of warehouses in Kjøpmannsgata, and Munkegata which is city´s parade street and main square (Fig. 5). The results show colours in ochres, reds and beige, all of them warm and subdued. The colour registration comprises colours which have been given to Trondheims historical architecture over the past 40 years, from the time of Arne E. Holm´s practice and the advisory of the municipal conservation office. The registration does not include color excavations and only records the state of the streets in the year 2015. The registration does however record a tradition of colours, as most of the buildings registered have been given colours by professional advice, based on knowledge of the city´s colour tradition. Further registrations and invenstigations may give more detailed knowledge of individual buildings colour history. However, as of now, the registrations are a tool for a strategy to continue to counter modern colour trends and give the historic city colour according to historic knowledge and a tradition which requires further delving into. While the Trondheim palette is the state of today, it must be developed into a more specific historic Trondheim palette, for future guidance on the colouring of the historic city.

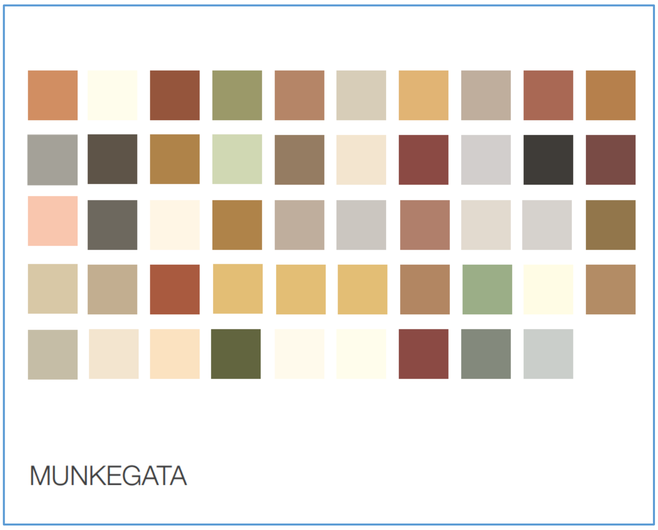

Fig. 5 – Color registration in Munkegatga (2015)

Conclusions

The colors of Trondheims historical buildings are not what we see today, on the specific level, but I would argue that the city image is representative of a traditional use of colours which is part of the city´s historic identity. Since the city established a onservation office 40 years ago, giving advice on the use of colour on buildings has been a regular task and this has contributed considerably to reclaiming status for buildings which especially in the post-war decades were an endangered species in the face of modernization and intensivated land use. After decades of modernization and trendy use of whites and brown, historic buildings were restored and painted in traditional reds, ochres and greens. Vernacular buidings were devised colour schemes based on a general knowledge of colour tradition, as there was often no original facade material on which to perform scientific color excavations. Professor Arne E. Holm´s examiniations in the early 1980´s of the buildings of Munkegata reveal that color excavations were performed where this was possible, but that sevaral other issues were decisive for the final result: the personal preference of the owners, as well as the assessment of the street as a whole, to achieve a harmonic whole, influenced the outcome. On listed buildings, color excavations were performed as a rule, sometimes revealing surprising and even undesiring results, when the findings differed vastly from previous knowledge and expectations as is demontrated in the examples of Granåsen and the white warehouse in Kjøpmannsgata. Also, historical accounts on what pigments were available tell a more varied colour history than we can see today, for example with the use of blue and bright green pigments. However the buildings and context in which these specific pigments were used are long since gone.

Trondheim historic wooden vernacular buildings in and around the city centre have undergone many changes over centuries and decades. Wooden cladding and architectural detail is vulnerable to change and renewal, and age value is not always present in the wooden vernacular. For these buildings, colour schemes are based on general knowledge of traditional colouring and old photographs. For listed buildings and buildings which are materially authentic, colour excavations are increasingly used to restore an original facade colour. Encouraging private owners to use paints with traditional binders is a more difficult task. With issues of maintanence intervals and lack of

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knowledge among modern paint firms on how to apply these paints, paints with traditional binders in the vast majority of cases lose in competition with modern paint systems.

We know enough about the colour history of the city to state that there is a tradition of colour use, and this has been the ground for advising on colour use over the past 40 years. Trondheim has a "palette" derived from a survey from 2015 on colour use on historic buildings today. What now is needed is to define a more complex and knowledge based "Historic Trondheim palette" which does not only register colour use on historical buildings over the past 40 years, but which can give a more specific knowledge about the actual historic use of colour before this, knowledge which was lost in the breach of tradition in the post-war decades.

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On different approaches to Environmental Colour Design

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Abstract

In 2022, the Study Group on Environmental Colour Design (SG ECD) of the International Colour Association (Association Internationale de la Couleur, AIC) is celebrating its 40th anniversary! The main goal of the SG ECD is to disseminate knowledge about experience made in the process of integrating colour in the planning, design, and realization of the built environment, exterior and interior spaces. The activities and events of the SG ECD have opened up exchanges between experts working in diverse countries around the world. At present the SG ECD includes approximately 300 members from 43 countries. The means of exchange include meetings, a website, a mailing list, and publications as well as collaborations with other groups and organizations to stimulate research and teaching related to the members' key interests. An SG ECD report is published in the AIC Annual Report. The Study Group on Environmental Colour Design was consolidated the following year at the AIC Interim Meeting on Colour Dynamics, which was held 8–10 June 1982 in Budapest. Nemcsics believed that architectural colour had been applied in a more conscious way ever since World War II. As well, it seemed to him that many professionals such as physiologists, psychologists, anthropologists and sociologists were investigating the effects of environmental colour on humans. Further, in physics and aesthetics, the relationship between colour sensation and colour composition and harmony were being newly investigated. Nemcsics thought that this variety of points of view and heterogeneous research results should evolve into a new science that he suggested calling Colour Dynamics. The aim of this new science was to gather together insights from different disciplines to create a theoretical and practical basis for the study of the relationship between colour, the environment and human response. In essence, environmental colour design concerned any design of the physical setting for human habitation and activities. As well, it also used to refer to aims and results in the applied arts and sciences in the creation of immediate manmade environments, such as in interior design and lighting design. More recently, however, the term implies ecological and sustainable design efforts including the protection of the environment and nature-friendly strategies. And lately, in terms of developments in the field of colour, colour design is playing a key role in creating ambience or atmosphere in indoor and outdoor spaces. Here the aim is to improve a sense of well-being and comfort through the construction of aesthetically appealing and environmentally friendly urban spaces. This presentation aims to explore different approaches to environmental colour design and glean answers to the question as to what role is to be attributed to theory in environmental colour design and how theorical concepts relate to colour practices and colour applications in urban design, architecture, exterior and interior spaces.

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8. Color and Design

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Fly in color. A chromatic "model" for the cabin of a commercial aircraft

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Abstract

The European research CASTLE (Cabin System Design Towards Passenger Wellbeing) puts the passenger's perception of well-being at the center of a prototype commercial aeronautics project. From this point of view, the evaluation of ergonomics and the travel experience become the objectives of an analysis of the space/context in which color, integrated with the functional components, of the shape and materials, becomes a tool for the concept design of the cabin space. The methodological approach developed therefore entrusts color to a primary role in defining the state of well-being and identity of the cabin space, through a "color model" that can be scaled in relation to the colors that each company will choose for its own color image.

Keywords: CMF design (colors, materials, finishes), UXD user experience design, HCD human centered design

Introduction

There are two factors that have the greatest impact on the flight experience. The first is the characteristics of each passenger (habits and behaviors), while the second is represented by the relationships that the passenger establishes with the components of the cabin in the different phases of flight. Therefore, the approach of a conscious designer will be to consider holistically the different components to improve the overall flight experience that is evaluated through the comfort indices. Referring to the evaluations of two well-known scholars of passenger comfort, Vink and Hallbeck, it is agreed that the difference between comfort and discomfort depends on the interaction between the "person" (which has its own characteristics), the "furniture component" (from the seat to the carpet) and the "task" expected by the person in that specific flight phase.

Comfort is affected by a set of elements that each person evaluates with a different weight according to their perception and which can be divided into four macro-groups (Di Salvo and Germak, 2019) to be addressed in a holistic way, i.e., without a specific hierarchy:

- "accessibility to services", i.e. the offer of conditions designed for passengers to find or choose their seat, to receive information and orient themselves, to have contact with the outside world (extended view);
- - "physical ergonomics", determined by the postures and movements necessary to perform an action, from sitting to accessibility to adjustments, for example, related to "proxemics", understood as the control of personal and social space (Ahmadpour, 2013);
- - the "psychological microclimate", i.e., the set of environmental components such as noise and vibrations, heat, humidity and the smell of the air, functional light (Ong, 2013);
- "the visual identity" of the space, determined by its size, organization and lighting, and of the surfaces of each piece of furniture, the perception of which is strongly correlated to the effects produced by ambient light and colors.

In recent years, all these elements have been the basis of design research for the aeronautical industry, even if individually evaluated according to different hierarchies (Torkashvand, Stephane and Vink, 2019). For example, the different relevance that the authors Bubb and Vink attribute to anthropometry in terms of ergonomics of posture and movement is known. In Bubb's assessment, anthropometry appears as the last of the factors that contribute to the perception of well-being, after smell, lights, vibration, noise and climate; evaluation overturned by Vink's analysis. These evaluations do not appear on a smaller scale aspect concerning the configuration of the cabin space and the relationships between these and the flight context. Aspects that, on the other hand, the most recent literature highlights as fundamental components of the design for the habitability of the cabin and which are influenced by the habits, behaviours and cultures to which passengers belong (Yao, Song and Vink, 2021). The integrated design of these "visual" aspects therefore concerns the setting up of the cabin as a complex space with which passengers interact during the flight phases. Today, the design makes use of overall perceptual evaluations on the four macro-groups described above, among which the visual identity is strongly influenced by light and color.

Fly in color. The importance of a color design

Some designers have been able to create, through lights and colors, real experiential environments, able to involve the passenger and mitigate the traditional visual discomforts related to air travel, such as the claustrophobic feeling generated by the small size of the space and the perceptive insecurity determined by the tunnel effect linked to the prevailing longitudinal dimension of the cabin. Other designers still push this research towards the creation of virtual relationships with the outside, such as in the simulations of artificial skies projected on the ceiling and multimedia effects involving side walls and partition walls (Bagassi et al., 2015).

Fly in color (Bianco, 2018) thus becomes a metaphor for the importance of color choices guided by a design project that integrates the different perceptual dimensions attributed to color: psychological, visual, functional and cultural.

Based on these considerations, the UXD PoliTo Team, in collaboration with the well-known design firm Pininfarina, has devised a cabin set-up concept aimed at reducing the tunnel effect and the claustrophobic one, integrating different design tools with each other: the configuration of the space in "virtual rooms" delimited by lighting elements and by the chromatic tonal variation of the seats in groups of three rows, the chromatic interaction of the back wall with the carpet and the sinuosity of the lining surfaces that envelop the space without continuity.

The areas of investigation on the influence of color are: the psyche, which investigates the factors of harmony/contrast, lightness/heaviness, heat/cold, liveliness or tediousness; the visual, which detects the incidence of contrasting factors between light and dark, the saturation of the surfaces and the feeling of proximity or distance; the function, perceived as an index of hygiene or a signaling/informative element; finally, culture, an area that often associates the color choices of the cabin components (mainly the seats) with the colors of the flag, logo and airline's territory (Fig. 1).

Based on our recent semi-immersive simulations of color cabin arrangements, it appears that there is no perceptual hierarchy between these four areas. The perception of color is in fact highly subjective and linked to the passenger's previous experience, to his cultural context and to the attention he pays to the search for the motivation and meaning of a specific color. Even in the field of university teaching, we see every day how the chromatic project is one of the foundations of basic design, which cannot be separated from the theory of configuration, which must deal in an integrated way with the components of form, material and color. (Anceschi, 2006)

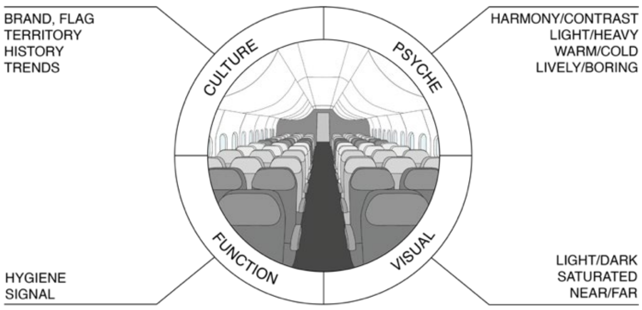

Fig. 1 – The four perceptual components of color in a commercial aircraft cabin.

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In the cabin chromatic project these attentions are still little considered, so much so that most airlines choose the color of their set-up not on the basis of a perceptive project, but for other reasons. From our analysis carried out in 2019 on the top 30 companies in the world according to SkyTrax (British research company), it is noted that the companies show a chromatic choice based on:

a. *color brand/flag* (47%), relating to the color scheme of your brand or flag. It is a chromatic choice that is not always intuitive but in the case of saturated and contrasting colors it can translate into a lively, dynamic and not boring space. Obviously, the opposite is also true, with the risk of strong impact color associations and tiring over time, as in the case of RyanAir with its highly memorable yellow and blue hues;

b. *color culture* (27%), oriented towards the use of colors and textures referring to the company's traditions and territory. It is an appreciated chromatic choice that enriches the perception of the setting with cultural meanings. An example in this sense is that of the Etihad company which uses colors that reflect the warm colors of the territory (sand) and the sea (blue);

c. *color context* (26%), aimed at communicating the perception of an interior space as a place of innovative technologies (see Apple Store) or prestige through harmonious colors and light colors. It is a chromatic choice with a historicized character and which requires control over the monotony and the balance between colors that follow the principle of gravity for which the heavy masses are at the bottom and with dark and saturated colors, the light ones at the top and with lighter colors and less saturated. Among the well-known examples is the AirBus Jets 350XWB designed by Pininfarina, in which the dominant white is contrasted by blue points on the seats and on the carpet.

Other data collected concern, again within the 30 companies of the SkyTrax report, the prevalent use of colors in the components that have the greatest impact on the color perception by the passenger: seats and headrests, corridor and cabin surfaces, the latter normally in homogeneous color between side and bottom walls. Obviously, the detection takes place regardless of the use of brand/flag colors, culture or context and in any case shows a prevalent adoption of shades of blue and gray with dominant red/brown. In fact, from the interviews conducted with the companies, a trend towards very cautious color projects emerges that refer to the known psychological effects activated by some colors considered relaxing and that seek harmony through the scaling of the tonality (Fig. 2).

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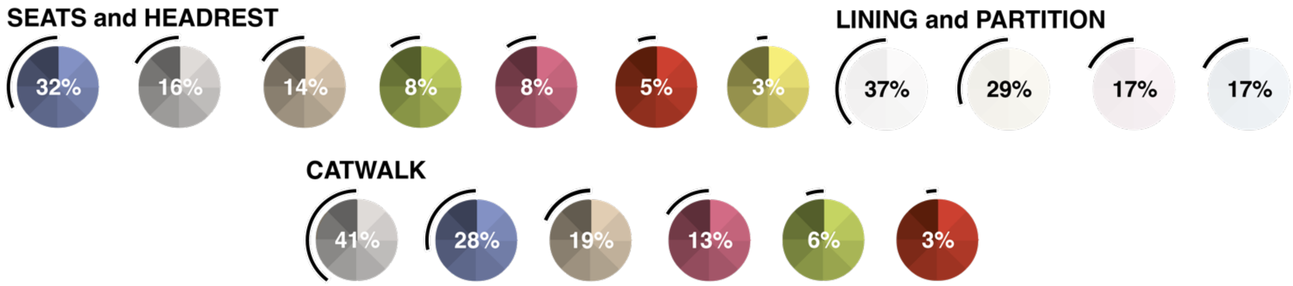

Fig. 2 – Prevalence of colors in the outfitting components of the 30 aircraft selected by the SkyTrax 2019 report.

The chromatic setting of the space/context

Among the uncomfortable situations most perceived by the passenger, the sensation of suffocation due to the narrowness of space and the insecurity related to the lack of perception of the end of the fuselage, the so-called "tunnel effect", are highlighted. We are helped by some considerations consolidated by Gestalt research, normally applied for the perceptual evaluation of the traditional built space. It must be said that some of these principles must be further re-elaborated in consideration of the atypical space of the fuselage, which is long, narrow and with a macroscopic impact of the backrest part of the seats. In addition, the perception of chromatic comfort can sometimes be influenced, at a functional level, by the difficulty of movement both in accessing the seat and in proceeding along the corridor. Some studies (Jaglraz, 2011) suggest using Gestalt principles to evaluate the perceptual variability when not the colors vary but the contrast between them, thus obtaining effects of enlargement, narrowing, lengthening, approach (Fig. 3).

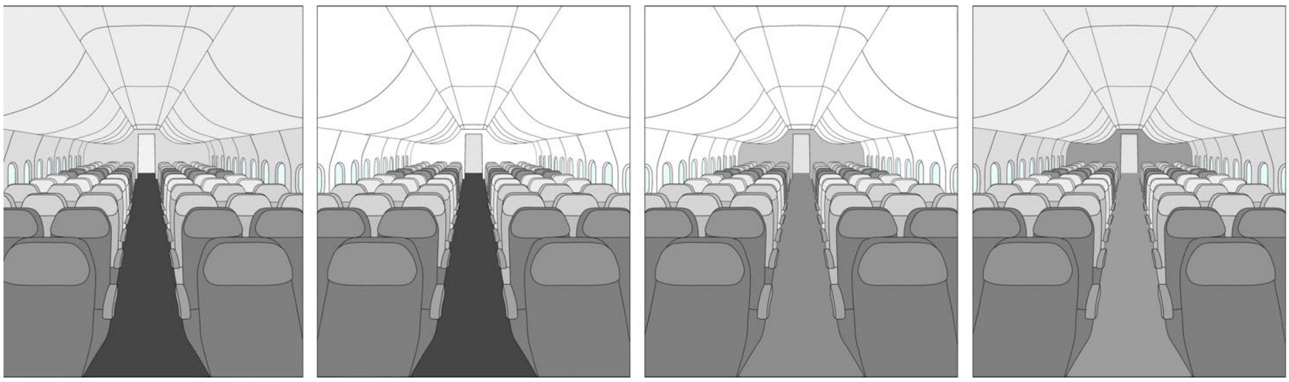

Fig. 3 – Gestalt perception of possible color combinations for the cabin space.

In association with these principles, going down to the scale of the seat, it was also understood how some color combinations of this component, extracted from the models compared in the SkyTrax study, affect both the dimensional perception and the static/dynamism of the space (Fig. 4):

a. the use of scalar shades on the horizontal rows of the seats, starting from the darkest in contact with the windows, gives a perception of "widening" of the cabin through the balance of the colors, which also varies according to the day/night time slot on the way of the light coming or not from the windows;

b. the chromatic organization of the seats for columns, in alternating dark/light colors leads to an effect opposite to that described above, highlighting the length of the cabin and thus also increasing the "tunnel effect";

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c. the “random” arrangement of shades in nuance gives a perception of homogeneity between rows and columns but at the same time a lively and dynamic aspect due to the contrast between the colors;

d. also, the organization by groups of rows with repetition of scalar shades considerably reduces the tunnel effect, giving at the same time a dynamic but balanced aspect in which attention must be paid to the chromatic choice for the back wall, as seen in figure 3.

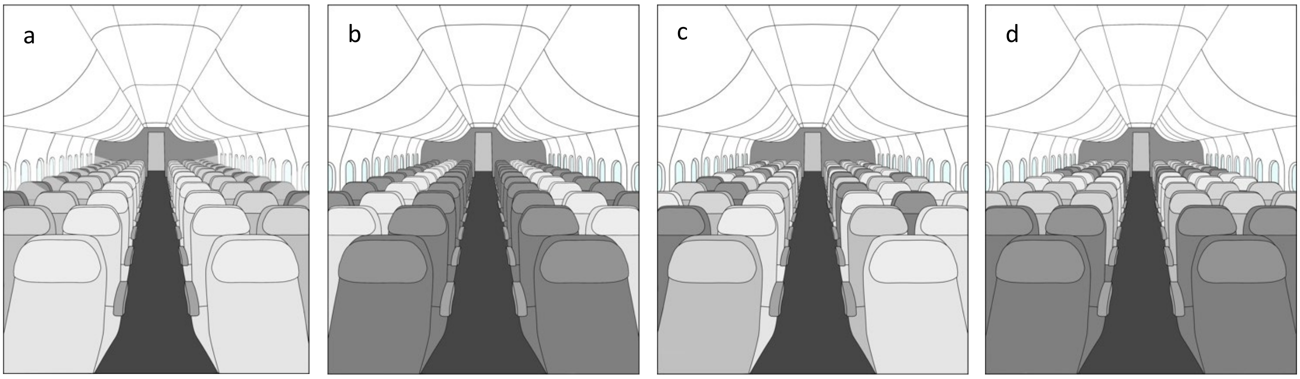

Fig. 4 – Gestalt perception of possible color combinations of the seats.

The CASTLE chromatic model

Considering as objectives the improvement of the perceptive comfort of the cabin through the color and the possibility that this can be declined in accordance with the specific identity of each individual company, the CASTLE model is not based on the priority identification of some colors over others but on the concept of color combination. To reduce the tunnel effect and the search for a dynamic identity of the space, the model proposes the creation of "rooms" defined by a scalar and rhythmic variation of the shades of the seats, accompanied by a luminous perimeter of groups of windows and PSU (passenger service unit). The design of the different components (side and back walls, ceiling, seats and carpet) immediately integrates color as a fundamental tool for recognizing the "rooms".

In a first co-design activity with "personas" (20 males and 20 females), chosen as a sample of ideal types of passengers by age, profession and nationality, the perceptual impact of the "room model” declined in different colors. The test was conceived as a meta-project evaluation of the subdivision into “rooms”, set up with different colors and scaled shades, based on the colors most used in the solutions described in the SkyTrax comparative report. The test was carried out with the projection of the cabin in real size on a large screen (7x4 m) and the personas standing, simulating his entry into the cabin from the service area.

During the session, the passenger was asked to evaluate how the space and environment were perceived in terms of stress, comfort, harmony, elegance and safety, giving these factors a value from zero to five. Furthermore, in the second part of the session, to evaluate the dynamism of the chromatic combinations, different sequences of scalar shades were proposed, for a maximum of 12 hypotheses visible for ten seconds each (Fig. 5).

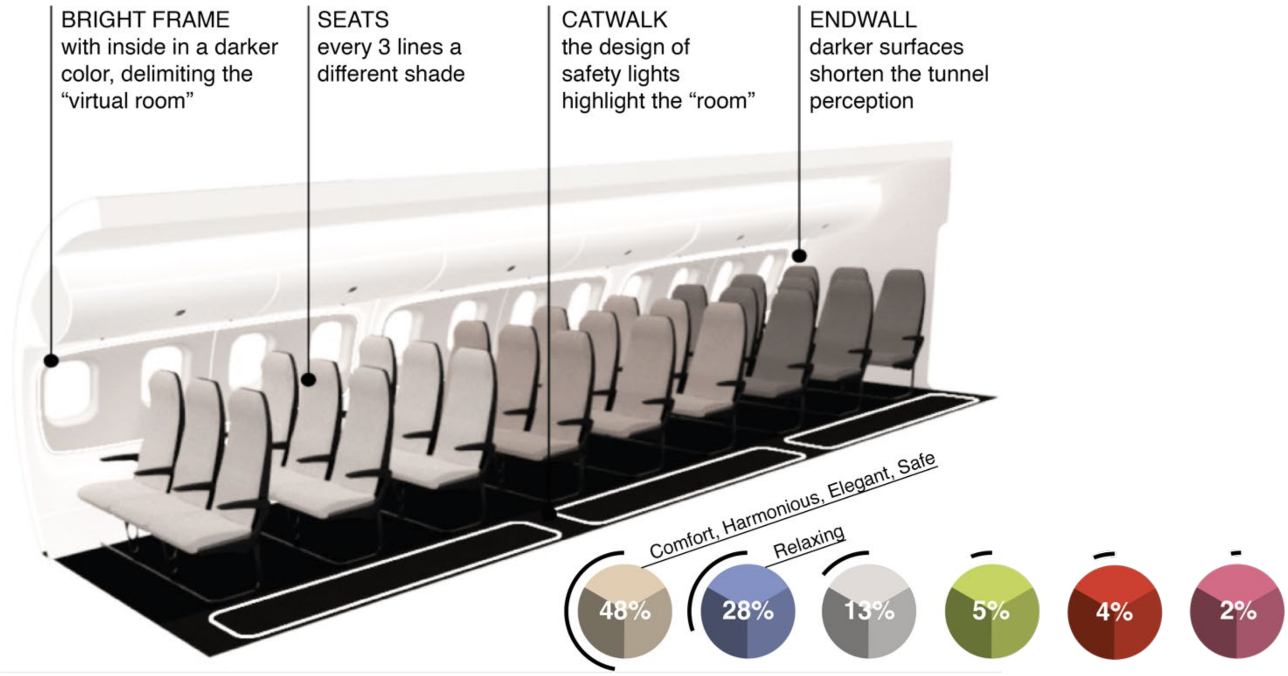

Fig. 5 – Summary diagram of the elements characterizing the color in the cabin and the percentages of appreciation of the different shades.

The influence of light

The contemporary approach to the design of passenger cabins considers the physical chromatic research integrated with that of light. The research therefore integrates, in a holistic way, the different parameters referring to the design of the luminaires, the color rendering of the light sources and the evaluation of consumption for the purposes of energy sustainability, a very important fact in flight. The light in the cabin must ensure two conditions of a functional and expressive nature: to make actions and movements operable safely and to characterize the perception of an environment consistent with the different phases of flight with adequate intensity and colors. In addition, the lighting design must also immediately deal with the design concept of the cabin space. This is to ensure both an average homogeneous illuminance coefficient, without glare and shadows, and a perception of light comfort in the two conditions, opposite or intermediate, of active lights or off lights.

Being a short/medium range aircraft, in which there are no specific flight phases such as meal or sleep, the lighting concept includes LEDs with standard color temperatures and intensity control managed by an onboard computer.

Based on the "CASTLE chromatic model", the measurements and lighting engineering evaluations therefore concerned the control of the average illuminance values on the surfaces colored in shades of dove gray, the preferred shade for the chromatic evaluation test. The sectioning of the system allows you to activate separately, also by intervening on the intensity, the 3 types of luminaires for ambient lighting: linear ceiling; wall frames every 4 windows to delimit the "virtual room"; frames of the PSU (passenger service unit) (Fig. 6).

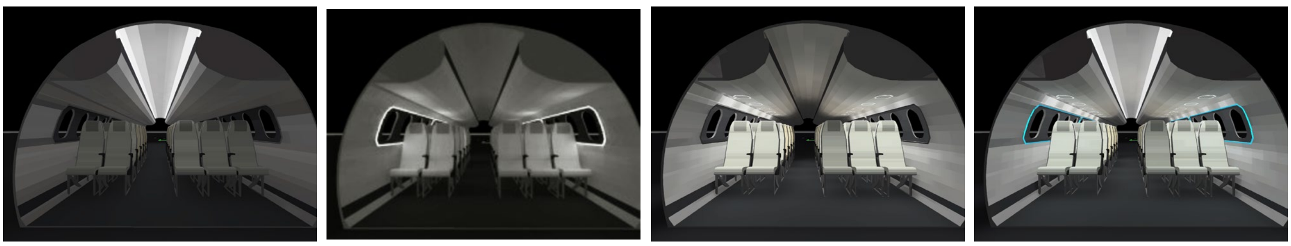

Fig. 6 – On the left, the 3 types of luminaires for ambient lighting: linear ceiling, wall frames every 4 windows for the delimitation of the "virtual room", frames of the PSU (passenger service unit); On the right, the three types active at the same time.

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Results and conclusions

A prototype is currently under construction (a section of the cabin which is functioning and mounted on a vibrating plate) equipped with all the components required by the cabin concept design, including the “chromatic model” with scalar shades grouped in the “virtual rooms”. In the autumn of 2022, the concept design will be validated through final tests with users and potential customers of the aircraft, based on the perception of the various parameters that contribute to flight comfort: structural/vibrational, functional relating to accessibility and movement, airiness and cabin lighting, validity of the concept design in the definition in "virtual rooms" and relative "chromatic model".

Precisely the "chromatic model" opens to further research developments. On the one hand, an in-depth study of the relationships between color and texture of the seats will be initiated (introducing the parameters of roughness and three-dimensionality of the fabrics), through Eye-Tracking tests that can be carried out with the user samples already selected. On the other hand, the prototype will allow an exploration of the opportunities offered by RGB LEDs. The environmental contribution provided by these sources today is still under study but presents excellent research opportunities to improve cabin comfort in relation to both the activities to be performed in the different phases of flight, and the color rendering of the surfaces, in particular walls and seats. The well-known layout of the Boeing 737 Sky Interior, in this sense, works a bit like a gym for the chromatic combinatorial possibilities offered by the colored light sources.

In collaboration between the DAD (Architecture and Design) and DENERG (Energy "Galileo Ferraris") departments, specific research has been launched on the use of colored light (RGB LED) in flight with an original approach. The chromatic variation of the light is in this case related, in the access, take-off and landing phases, to the temperature and humidity conditions of the external environment, to reduce the perception of sudden changes in temperature (Fig. 7).

Fig. 7 – The preparation of the CASTLE cabin (concept design in collaboration with Pininfarina) with white light LEDs and possible variation of intensity and color through RGB LEDs.

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Chromatic identity of the urban tile panels: the scenario of Lisbon subway stations

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Abstract

This paper aims to create a deeper understanding of the influence of tile's panels to the image (graphic and symbolic) of Lisbon subway stations, and their input to qualify user experience. For that, 3 case studies will be analyzed (focused on defining and registering the predominant colors, on the message associated with the graphics represented, the reason beyond their choice and application, as well as their contribute to the feeling of security, visual comfort, orientation, and aesthetic pleasure of the user) to a broader understanding and further discussion.

Keywords: Tiles chromaticity and patterns, Smart cities, User experience, Imagery, Subway stations of Lisbon.

Introduction

The city is a living organism described by its economic, social, and cultural dynamics. Metropolitan areas are becoming smart environments and this concept strongly relates to the cultural identity of the place and the mechanisms that improve user interactions throughout the delight of the experience. Color is a significant element of the identity of the place and contributes significantly to the user's experience of it. The diversified users' experiences, supported by human daily routines and interactions are significant components of the place's identity. The plenitude of users' experiences in a particular place is granted by built environ, geographical location and orientation, the shape of buildings and equipment (as well as the finishing materials identifiers of constructive processes and / or traditional practices), cultures and contemporaneous trends. With the city of Lisbon as a backdrop scenario, it is possible to explore its urban tissue and identify the diverse cultures or the sequential gentrification processes that Lisbon suffered from the first millennium, with particular emphasis on the Arab occupation and its tiling mode – adding a new skin to the facades - highlighted by its geometric and chromatic patterns. Despite such cultural heritage, the last decades witnessed a proliferation of achromatic paletas to respond to modernism requirements and trends that follow acknowledged names of Portuguese architecture. Therefore, the tile panels were relegated to mural panels on city crossing points and subway stations, acting like a tattoo on the built skin, with monochromatic and / or polychromatic graphics pattern, contributing to a figurative and symbolic image of the place. Smart cities aim to develop new ways of transportation, and the public ones, such as the subway, emphasizes their importance. Subway stations are places where a considerable number of individuals interact with the space and with each other while waiting for transport. The ambience offered is of major importance to ease waiting times along with overcrowding at peak times. More than the finishing of the building, the wall and / or the object, tiles panels are constituents of semiotics and Lisbon's imagery, and subway stations are one active part of the city to achieve the smart label.

Case studies contextualization

The unbalance between regions, namely the dichotomy formed by metropolitan and remote areas, the climate changes and the development of ICT contribute significantly for the emergence of Smart city concept. Regardless urban area's geographic location and dimension, dissimilar cities aim to be a smart one. A Smart city is the urban area that promotes a sustainable development and high quality of life for users, despite their nature, throughout the conscious management of key areas such as government, economy, environment, mobility, living and people (Business dictionary). The purpose is to optimize urban area's functions to promote economic growth as well as quality of life for individuals using smart technologies and data analysis (European Commission). Beyond technology, the smartness of the city demands the respect of the sustainable and inclusive conceptual framework.

Public transportation, in particular the underground subway system, responds to sustainable and inclusive conceptual frameworks and, with the support of smart technology witnessed the improvement of its performance. The underground subway system is a trendy way to commute in metropolitan urban areas. Its success is based on the balance between the distances covered and the time spent on the journey, by the avoidance of traffic lights and jams allowing the travelling from A to B for a considerable number of commuters. Its existence dates to the 20^{th} century, and it has expanded its influence from city center to remote boundaries. If the functional performance of the underground subway system responds to environmental and economic sustainability, its physical environment comprehended by corridors and platforms respond to social sustainability and inclusion. Throughout corridors, intersections and platforms, a varied community interacts with each other and with the physical environment. Commuters, meet up and interact through distinct schedule patterns, regardless age, race, social, religious, political preferences, and realities. In a physical environment responsive to technical functionalism advancements but repeatedly associated with insecurity, deficient air quality, and lack of cleanliness, the stated interactions impact significantly the users' experience of the underground rail system. To qualify the commuter experience, art emerges as a critical issue to encourage the creation of meaning and transform the spatial environment in a place to which commuters want to belong. The adoption for art and culture within underground subway environments improves the commuting experience: throughout the design of a safe and stimulating surrounding; the commitment with local people and industries to build up a sense of ownership and pride with urban and underground subway station areas; the easy and free access to art, all to the cultural prestige of the station and the urban area as enhances the commuting experience (Welsh, 2012).

Underground railway stations physical environment

"Subways are increasingly being used as a meeting place of the arts" Marianne Ström

The physical environment of underground subway stations aims to provide the access to people from aboveground to this public transport. They were conceived in the same way as streets, avenues, and plazas to achieve the best pathway to user attain its destination. Spatial configuration and associated functionalities define users' behaviors. Thus, there are spaces considered as decision ones, those that support users' priorities or preferences, such as entrances, tickets offices, corridors junctions; movement spaces, the ones that aim to connect the decision spaces, namely corridors and junctions to change the desired destination; and the opportunity spaces, those related with interchange area, outside the movement and decision spaces (Transport for London, 2012). Despite their nature, these spaces were designed as an infrastructure, supported by technical development and capital investment principles, disregarding their social potential and the needed attention to place making.

The physical configuration and intensive daily use by the commuters' community grants their understanding as "public spaces for everyday use, civic centers, financial vehicles for expensive public transport infrastructures, architectural symbols, and social and cultural assets. (Lee, 2018, pg. 222). Place Making attends to transform public spaces into places that represent significance for individuals, offering them the pleasure of their experience while creating feelings and memories. Place Making aims to attain a significant civic commitment, social and economic advancement,

cultural awareness and strengthen the relationship of people with the environment in which they are inserted, through participatory procedures and creative outcomes (Vichealth, 2006).
The introduction of art and culture - despite its form and/or nature - in underground environs, impacts significantly in making place process. If art and culture contribute to the vitalization of these environs, in a continuous or ephemerous way, architecture emerge with a permanent character contributing to the construction of the place and frequently transform this space of transition to the destination improving the experience of commuters and tourists (Lee, 2018). A place can be understood as a intricated sensorial experience, that implies a collection of physical and cognitive experiences that settle on human and non-human actors (Crouch, 2010). The sensorial experience, offered by architecture, finishing materials, painting, sculpture, and live performances, acts as a signs' map that guide the user's destination path and concurrently stimulates the human senses. Although technical and aesthetical improvements were critical to qualify underground spaces/places, the focus on aesthetics attributes relieves users' psychological concerns. The art and culture promote the pleasure of the experience; however, it is the commuters' community that grants to the art and culture symbolism and meaning. Users' commitment throughout art and culture practices, generates more humanized spaces, boosting the sense of belonging which often nurtures an ethic of care to other beings and to the environment while increases the sense of security (Vichealth, 2006).
The commuters' experience of underground subway stations is guided by the time spent in transit through the access corridors and the platforms for transport's waiting time, which, combined with security issues, somehow intensified by deficient light, lack of cleanliness and poor air quality these emerge as the principal sources of users' anxiety. Beyond these questions commonly accepted, boredom is a problematic issue repeatedly neglected. The introduction of art and culture in these environments can contribute to mitigate the stated related questions (Siegel, 2018). The public space that involves and interacts with users through inclusion, inspiration, beauty, and creativity boosts individuals' mental health and wellbeing (Zint, 2020) and qualifies the experience.

Lisbon underground environments, the importance of color

The commuters' community experience in underground environments qualifies for the possibility of interactions, promoted by the spatial layout, among human and non-human actors. The human interactions with the space require the perception of it demanding spatial features that appeal and stimulate human senses. Knowing that the predominant sense is that of vision, thus, color emerges as a critical quality of the space. Despite material, context, sight direction, light and user's features, color is critical to improve the understanding of functional areas, way finding schemes, and throughout composition, harmony and contrasts, color improves the aesthetical quality of the place, granting the pleasure of its contemplation and experience and the symbolism assigned by users' heterogeneity. The main purpose is to use color to build up a place that fosters social interactions and relationships, throughout the stimulation of human senses to feelings and behaviors, and simultaneously forms the identity of the place.

Fig. 1 – Lisbon Metropolitan and red line maps. Source Metropolitan of Lisbon 2022.

Case studies

To illustrate what was expressed in the above sections, three case studies were approached that are an integral part of the most recent line of the Lisbon Metropolitan - the **Red Line**. This line connects the city with the airport and long-distance trains, and it was built with the initial intention of allowing the access of a considerable number of visitants to the 1998 International Exhibition. Therefore, three stations from this line where chosen; **São Sebastião**, the Red Line initial station, and the less chromatic of the case studies; **Olaias**, an important station for its architectural and chromatic traits; and **Oriente**, the primarily final station of this line.

- **São Sebastião**

This station was built in 1959 as part of the Metro Blue Line. In 1998, the creation of the Red Line to serve a new area of the city, it was critical to create a connection to the previous lines. One of the connection spots was created in São Sebastião. Due to the need of serving two lines, São Sebastião became a double station: São Sebastião I, with a platform on the blue line, and São Sebastião II, with another platform, on the red line. However, at that time, no attention was given to the need of its decoration, and only in 2009, the station ambience emerges when it was remodeled with a project by Maria Keil, the artist responsible for the decoration of São Sebastião I in the year of 1959. The project for the new station had the collaboration of two architects, Catarina and Rita Almada Negreiros. The new project seeks to establish a relationship between the two metro lines and, associate the paths along the ways to and out of the trains. Therefore, it starts from the traditional tiles applied as a module of various patterns. Then, Maria Keil explores the possible transformations of the tiles, thru light, colors, shapes and textures, establishing the dialogue with the users all over the tiles' composition which introduce the rhythms of departures and arrivals. It is important to mention that Maria Keil artistic work was pioneered in the conception of underground stations environs. The first subway stations were conceived by the architect Keil do Amaral, her husband, and due to the reduced governmental financial budget, she offered her artistic work to contribute for the aesthetical appearance and humanization of a predominantly technical environment. Her offer was accepted because of the tiles' cost and maintenance. Maria Keil allowed that this traditional construction technique was preserved and disseminated while reaching a high level of the city's identity (Metropolitano de Lisboa, 2022; Leitão, 2017).

Fig. 2 – Maria Keil tiles in São Sebastião I station. Source: Margarida Gamito, 2022.

São Sebastião I:

For this upper station, Maria Keil sought to make a connection to Parque Eduardo VII and the Gulbenkian Gardens, creating individual tile panels introducing trees in shades of blue, green, and pink, on a white background. These panels are part of a composition which includes also abstract patterns, in blue and white and pink, towards a geometric deconstruction ending in a predominance of white in the station dock.

Fig.3 – Application of Maria Keil tiles in São Sebastião II station, by Catarina and Rita Almada Negreiros. Source: Margarida Gamito, 2022.

São Sebastião II:

The project for this station is based on volumetric tiles that are grouped in panels that establish a vertical rhythm predominantly white, with some occasional vertical stripes in the colors that are displayed in São Sebastião I. These tile bands evoke the speed of trains arriving and departing.

- **Olaias**

In the year 2012, this station was considered one of the most beautiful metro stations in Europe by CNN's Impact Your World. This station is in an intermediate position on the Red Line and serves the district of the same name. This station was conceived by the architect Tomás Taveira, also the author of the architecture of the neighborhood, and the similar features displayed in both environments, allow to identify their relationship. The territory conditions of the implantation site allowed the construction of a very wide nave, with a large ceiling height, uncommon in underground spaces. Its decoration is composed of large white panels interspersed with high chromatic ones in blue, red and yellow, corresponding to the author's usual mark, all of them edged in black.

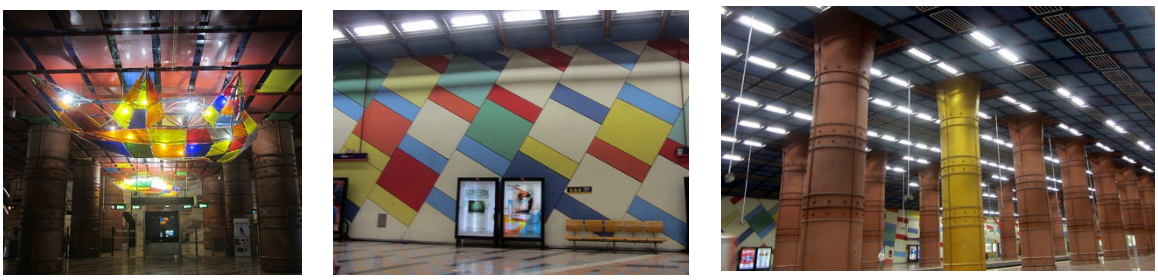

Fig. 4 – Entrance and nave of Olaias station. Source: Margarida Gamito, 2022.

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Due to the platform dimensions and the quality of its light, the station offers the sensation of not being in an underground space, and we are almost able to compare this space to the nave of a cathedral, which is accentuated by a double line of majestic columns that embroider the platform of arrivals and departures. Going up, we come across another line of decoration, more nocturnal, although profusely colored with luminous sculptures, also by Tomás Taveira, which give the entrance to the station a particular character, perceived as the stained glasses of a spiritual environment or the joyful coloring of a festive atmosphere (Metropolitano de Lisboa, 2022). Several artists contributed to the station decoration as it is the case of: Pedro Cabrita Reis, Graça Pereira Coutinho, Pedro Calapez and Rui Sanchez.

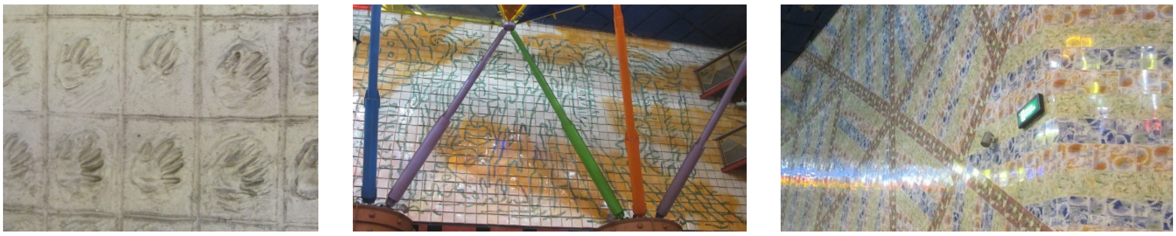

Fig.5– Tiles Panels for Olaias station from Graça Coutinho, Pedro Calapez and Tomás Taveira. Source: Margarida Gamito, 2022.

- **Oriente**

The Oriente underground subway station, the busiest one of the selected case studies, serves the urban area where the 1998 International Exhibition was located and which is actually a modern neighborhood that includes residential, commercial and administrative areas. It was conceived by the architect Sanchez Jorge who was inspired by the main theme of Expo 98 - the oceans - suggesting in its exterior structure an allegory of sails and boat prows which theme continues in its interior.

Fig.6–Panels from Abdoulaye Konaté (Mali), representing the oceans. Source: Margarida Gamito, 2022.

To enhance the vast space of the nave, eleven artists from around the world were invited to decorate station. From those artists, ten of them contributed with large panels of tiles inspired by the oceans theme, and one of them, Magdalena Abakanowicz, from Poland, did not use tiles, but instead, created a large sculpture. The application of all these panels along the station walls, create large patches of color, and transform this space in a permanent Art Exhibition (Metropolitano de Lisboa, 2022).

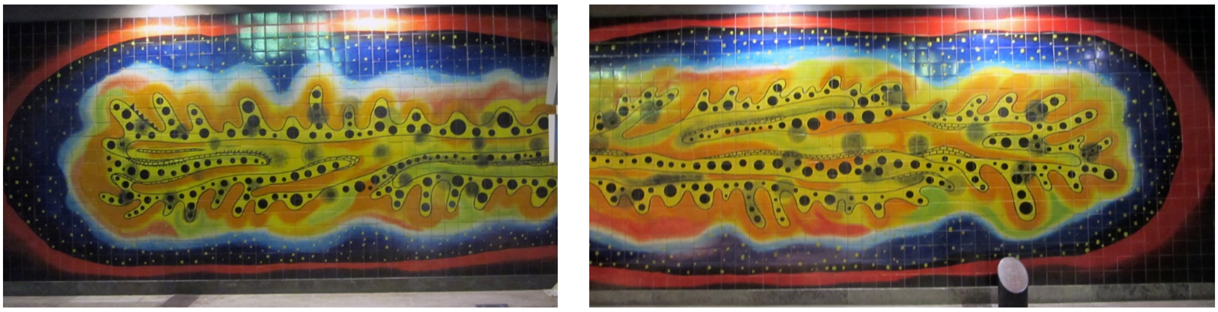

Fig.7– Two colorful panels from Yayoi-Kusama (Japan). Source: Margarida Gamito, 2022.

Fig.8– Sculture representing a large fish, from Magdalena Abakanowicz (Poland). Source: Margarida Gamito, 2022.

Conclusions

The tiles' panels were abandoned from the building facades of Lisbon city to respond to fashion and trends and architecture artistic movements. The use of tiles in Lisbon building facades was a way to preserve a traditional material and process of composition, from geometric patterns and colors, enhancing the cultural heritage of Arab influence on the territory. The recent times witnessed the relegation of tiles to murals and underground subway stations, maintain, however, their chromatic and pattern design qualities. The tiles application in underground subways stations is the context of our research. The pioneer of the use of this material in this context was Maria Keil, who offered her artistic work to provide a qualified ambience in the first underground subway stations of Lisbon's city. Her work, along with the work of other artists and architects, humanized these environments strongly marked by technology and related developments.

The commuters' community is characterized by its heterogeneity, however, despite differences and similarities people interacts with each other and with the environment. To boost these interactions the spatial features are critical. Literature review highlights the importance of art exhibition, despite nature and /or form to qualify the user experience in underground subway environs. Throughout art people develop a sense of belonging in relation to space, transforming it into a place. The tiles' panels embellish the place and via patterns design and chromatic palette promote visual comfort, an informal wayfinding scheme and aesthetical pleasure. The existence of these tiles' panels stimulates the existence of commuters, visitors, and tourists. Even though this art exhibition can be more appealing to visitors and tourists, once commuters experience it every single day, it is certain that its disruption would be felt in times of orientation needed and waiting times tedious.

Regardless the aesthetical pleasure provoked by the patterns design and chromatic effects, we do believe that the most important is light. Light intensity and orientation reveal colors, patterns and invites the users' sight. The light emphasizes the sense of cleanness as well as the sense of the security. The visits to the underground subway station in study, allow to understand that the use of white tiles with different textures and orientation, in the São Sebastião II, are less attractive which is due to the deficient illumination which do not offer a clear understanding of the artist intention. In contrast, São Sebastião I, with the tiles' panels with the representation of trees mismatching the exterior environment, are frequently scenario for photographers. Curiously the site that allows a more relaxed behavior from the users is the one from Olaias and we do believe that is a result of the

layout, more spacious, and mainly from the amount of light that floods the space. The underground subway station of Oriente, despite the interest caused by the thematic tiles' panels from different artists, its narrowed platforms layout and the insufficient light offers it a dark atmosphere, which in peak hours do not help in the sense of security.
Tiles, despite their patterns design and chromatic palette depend on light to express the features of the material and the intentions of their authors, otherwise is just and ancient and inexpensive material. Art exhibition, regardless all the qualities identified by literature review as well as the case studies selected, depends on light and space layout to undoubtedly qualify the user experience, confirming the crucial relationship between color and light.

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Research on Colour in Industrial Design: Brief History, Overview of Methods and Stories of Successful Products

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Abstract

Colour in industrial design is a subject that has been considered from both scientific and artistic positions, but has primarily been the domain of practitioners making choices for technological, functional and marketing reasons. The development of design education, whose milestone was the Bauhaus, based colour design on scientific theories, created by artists and art theorists, in which aspects of visual perception and subjective experience of colour were the most important. The authors of the most famous books on colour theory were Josef Albers and Johannes Itten, and the titles "Interaction of colour" and "The art of colour" remain the most popular reference books used in the training of designers. (Calvo Ivanovic 2022). The aim of this paper is to present selected examples of the role of colour in product design, significant from the point of view of authors of books on the history of design (Fiell and Fiell, 2013; Miller, 2009; Sparke, 2009). The selection of examples aims to analyse the different methods and meanings of colour in product design and the contribution of colour to a product's commercial success.

The paper analyses 8 famous projects from the years 1950-2006 whose colours introduced significant changes in the approach to product colour design. An attempt is made to indicate the design methods and basic design criteria that influenced the choice of colours from an aesthetic, semantic and functional point of view.

Keywords: colour design, colour palette, industrial design, design history, colour marketing

Introduction

The study of colour in industrial design presents many difficulties for various reasons. Design itself as a discipline, clearly distinguished as a field of study and as a profession requiring specific knowledge and skills, began to spread in the 1920s. Many textbooks on the history of design begin the history of the discipline in the 19th century - this is linked to the begging of industrial mass production and the recognition by architects, artists and art historians of the low aesthetic level of objects produced by industry. Both design itself and the theoretical discipline that studies its history were born in the field of art. This significantly influenced both the scope of interest and the methodology used. The assumption that design does not have to be art emerged as early as the 1940s and consequently brought about different historical interpretations (Mrozek, 2020) Design itself also formulates separate goals from artistic ones within its own field. Such goals can be: shaping functional form (functionalism, ergonomics), satisfying the real needs of users (social design trend), creating new needs (consumerism), complex problem solving (scientific operationalism), ecological design {design for sustainable development} or ethical design (design for all).

Colour in mass production became widespread after the Second World War, when, thanks to the spread of plastics technology and the use of materials such as melamine, ABS, polycarbonate and polypropylene. In books on the history of design, colour occupies very little space and an explanation of the designer's criteria for selecting a product's colour palette rarely appears. An attempt to analyze the colour palette of products was made by David Harrison (Harrison 2021), identifying 250 examples of innovative objects whose colour contributed to the commercial success of the product. The choice of colour in industrial design is driven by many factors, such as the form and size of the object, the function of the product, the material and technology, the colour preferences of the audience, colour trends, brand identity, among others. At the same time, the product designer or the colour consultant working with him or her usually has a background in colour knowledge from his or her artistic training.

In my paper, I want to demonstrate, using eight products as examples, that colour is an essential element in defining a product's image and can give it a prominent place in design history. The products I have chosen appear in review publications on the history of design, and their authors were famous designers. The time of the designs varies - the oldest dates from 1950, the most recent from 2005 - but what they have in common is that they are design icons, well known to design historians and students and lecturers at design faculties, and their colour palettes were milestones that introduced significant changes in the way we think about certain types of products.

Working with materials. Moulded Fiberglass Chairs – Charles and Ray Eames for Henry Miller, 1950

The Fiberglass Chairs were launched on the market in 1950, introducing a new furniture typology that has since become widespread: the multifunctional chair whose shell can be combined with a variety of bases to serve different purposes. Produced in chair and armchair form, the shells were moulded from glass fibre-reinforced polyester resin, which until then had been primarily restricted to military applications such as aircraft radomes and cockpit covers (Wilhide, 2020). Fibreglass offered the added advantage of pleasant tactile qualities and a perfectly moulded form for optimal comfort. Charles and Ray attached great importance to the use of colours – as fibreglass had previously only existed in a colourless version (vitra.com, 2022). Ray was educated as a painter and had a legendary memory for colour (Jongerius, 2016) The Eames spent many days in the factory, mixing hues for countless prototypes. 1st generation of Eames Fiberglass Plastic Chair were available in 6 colours: Elephant Hide Grey, Red Orange, Lemon Yellow, Greige, Parchment, Sea Foam (eames.com, 2022). In the subsequent years, the colour palette was expanded eventually reaching 27 colours, which gave the customers enormous freedom to bring personality to their home or work environment (Harrison, 2020). The Mid-Century palette expresses the optimism of designers working toward new solutions for living (Eiseman, 2011). Ray and Charles Eams' aim was to provide the public with low-cost, durable furniture with a colour palette suitable for a variety of interiors. The Eames Plastic Chair was the first mass-produced plastic furniture without upholstery (Fiell, 2015)

Colour marketing. Cadillac Coupe de Ville, General Motors – Harley Earl, 1959

The driving force of the American economy after World War II became mass consumption and colour design turned into a scientific process to optimise the choice of colour palette that would bring commercial success to the company (Fiell, 2013). Harley Earl led the largest, most influential styling department at General Motors Technical Center outside Detroit, which employed 500 stylists, engineers and experts on color and trim. The colorists and chemists at DuPont's finishes division in Detroit consulted with automotive stylists and shared the data from market surveys on consumers' tastes (Blaszczyk, 2012). The palette had to be decided 24 months before the December auto shows and the color stylists used all available tools: color forecasts (Duco), dealers sales evaluations, reports from customer research and advice from external experts. The major objectives were to ensure fashion correctness for the model year, in order to be sure that clients will accept the proposed colour palette. (Fiell, 2013). The 1959 Cadillac Coupe de Ville is remembered for its huge

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sharp taffins with dual bullet tail lights. In the 1950s, Cadillac was firmly established as the most prestigious car made in America. When one thinks of the Cadillac, the first thing that comes to mind is a picture of Elvis Presley's car in the iconic pink color. In fact, such a paint did not appear in the color palette of Cadillac models for 1959 and Presley's car was repainted in this color at the owner's request. By 1955, 40 percent of drivers were female. Harley Earl drew on GM customer research that women decided on color of a family new car 64 percent of the time. By 1958, GM Styling was home to the “Damsels of Detroit”, a small group of nine professionally trained women designers. They helped GM imagine what women wanted in interior design and color (Blaszyk, 2011). In 1959, GM's color palette for Cadillacs included the following colors (CLC-Color-Database): Dover White (DDL 8160), Silver (DDL), London Grey (DDL), Brenton Blue (DDL), Georgian Blue (DDL), Dunstan Blue (DDL), Vegas Turquoise (DDL), Pinehurst Green (DDL), Inverness Green (DDL), Kensington Green (DDL), Gotham Gold (DDL), Beaumont Beige (DDL), Wood Rose (DDL), Seminole Red (DDL), Olympic White (DDL), Argent (DDL), Argyle Blue (DDL), Hampton Green (DDL), Persian Sand (DDL).

Storytelling. Valentine Portable Typewriter – Ettore Sottsass for Olivetti, 1969

In the early 1960s, technological developments in the plastics industry resulted in the invention of new materials such as polypropylene and ABS. They were suitable for mass production by injection molding and offered enormous color choices. Plastics democratized avant-garde design that could enter the mass market. (Fiell, 2013) Ettore Sottsass created Valentine Portable Typewriter in collaboration with British designer Perry King and it was one of five typewriters that Sottsass designed for Olivetti during his twenty- two years’ collaboration with the company. Valentine was produced in 4 color versions with the characteristic high saturation of the period: red, green, blue and white. It was the first portable typewriter, which was intended by the designer to change the image of the device from a serious office item to a fun, lightweight and provocative object. “The Valentine is an object that says a lot about Sottsass and about his passion for colour. It demonstrates his imagination and his ability to take a humble everyday object churned out in tens of thousands by factory workers and give it identity” (Sudjic, 2016) The typewriter was launched on Valentine's day 1969. The product's advertising campaign included a number of posters, designed by some of the most famous graphic designers, such as Milton Glaser. Although there were a few color versions of the product, Valentine will forever remain a "red typewriter."

Colour and Form. Black 201 Television Set – Richard Sapper and Marco Zanuso for Brionvega, 1969

The Black 201 TV, designed by Richard Sapper and Marco Zanuso, was a precursor to the minimalist matt black style popular in the late 1970s (Wilhide, 2016). The Black based its identity on the purity of its geometry, a black cube that appeared to integrate screen with case in an entirely seamless way. When the TV is off, the screen is invisible. Here was abstraction concentrated in a surreal object whose image appeared and disappeared. The black color visually diminished the cube form emphasizing the message of miniaturization and mobility. In this case, shape and color are united, emphasizing the innovation of the product.

Matter of Taste. Tahiti Table Lamp – Ettore Sottsass, Memphis (1981)

The Memphis Group' designs were an expression of opposition to Good Design, which became widespread after World War II. The designers challenged the main principle of modernism, that form follows function. They believed that design was a phenomenon strongly connected to fashion and as ephemeral as it was. Their work was a collage of different styles and influences - Memphis members took Art Deco and Pop Art as their reference point, with a particular emphasis on kitsch and futurism.The group was international in character and, in addition to founder Ettore Sottsass, included: Andrea Branzi, Aldo Cibic, Michele de Lucchi, Nathalie du Pasquier, Hans Hollein, Arata Isozaki, Shiro Kuramata, Matteo Thun, Javier Mariscal, Luciano Paccagnella, George Sowden, Marco Zanini, Barbara Radice. The group's first exhibition was held in Milan in 1981. Tahiti Table Lamp is a signature object of the Memphis Group. Its color palette is polychromatic, consisting of pastel pink, intense yellow, red, black and brown hues. Sottsass used a laminate in the design, with a black and white Bacterio pattern he designed. Mixing of different patterns and colors, gave Memphis its shock value in the early 1980's. This set of colors was later to become a recognizable element of the "Memphis" style, which has been experiencing a renaissance in recent years. The product is situated at the intersection of art and design, making a program statement from the creator. In this case, "form follows meaning" (Sparke, 2009). Sottsass called it a way of rejecting the principles of good taste by "quoting from suburbia." (The New York Times, 2006)

Product customization. Nokia 5110 – Frank Nuovo for Nokia, (1998)

Frank Nouvo designed the Nokia 5110 phone as one of the first consumer models. Ergonomics was an extremely important aspect of the design and the designer's goal was to give the keys the right size and layout. Made of ABS and polycarbonate . the product had an achromatic color scheme, conforming to the standards adopted in the 1990s for cell phones. An innovative design premise was that the product could be personalized. Nuovo designed a series of color top covers, under the name Xpress-on. The user could repeatedly change the color of his phone. The proposed color palette included 'Antiqua Red, 'Bermuda Blue', 'Island Yellow', 'Geeko Green', 'Shark Silver' and 'Tango Orange'. The Nokia 5110 became the first phone to offer personalization, a feature that has become standard in the 21st century, when a new phone case market has emerged in myriad variations of colors, designs and materials.

Brand Image. iMac G3 – Jonathan Ive for Apple (1998)

The genius of Apple was in its intelligent approach to the way in which people interacted with its products (Sudjic, 142) iMac G3 was the first Apple design credited to Apple’s later chief design officer, Jonathan ‘Jony’ Ive. Beatrice Santiccioli participated in the project as a color consultant. According to her, the most difficult part of the project was simulating the colors that would later be made from the translucent PC/ABS blend. After making color samples by hand, Santiccioli dissolved the dye in water and tested different degrees of transparency by adding opaque-white pigment (Tan, 2011). iMac was initially released in Bondi Blue, and its gigantic sales encouraged the company to release a "fruit" series in 1999 with colors that would have been unthinkable in the computer industry until then. „Sorry, no beige” was a simple three word advertisement. (Harrison, 166) The iMac represented a complete vision; colour and material were just a part of it. Before the iMac, the computer world was very homogenous in terms of colour. "Computer beige" seemed to be a natural feature of electronic devices of various brands.. What the iMac did with its vibrant palette, translucent material and unique friendly shape was to give the user a fresh, new experience. Suddenly a functional device was also an object that was fun to use and have at home. The colour palette was not based on specific consumer group or sales regions. They were to be an integral part of the product design.

Colour Instability. Polder Sofa – Hella Jongerius for Vitra (2005)

Color changes under the influence of different factors is the basic difficulty faced by manufacturers. Obtaining the same color in different materials and under different conditions of light is often an impossible task and preventing matamerism effects is a basic requirement when combining product components. Dutch designer Hella Jongerius has made this variability the leitmotif of her designs. Polder Sofa was designed in 2005 for Vitra in four color versions: red, green, dark and light. In each case, the sofa is upholstered in 6 different materials, gently varying in color. This gives the effect of imperfection, typical of unique artisan products. The interest in how colour is affected by the changing nuances of light is what characterizes her approach. While Pantone, NCS and others have created systems for accurate replication of colours, Jongerius sees heself as rebelling 'against the flatness of the conventional colour industry'. (Harris, 2020)

Conclusions

- Color is closely related to material and technology. Sometimes finding the right colors is the result of experimentation rather than a preconceived plan. Due to the development of many new materials and finishes, CMF is a design specialty that is now in high demand, but it has always been a significant part of the design process.
- Colour is a powerful marketing tool. The use of information on colour trends, sales results and knowledge of the audience's colour preferences are a necessary part of introducing new colours into mass production.
- Colours stimulate the imagination and tell stories. Colour can give an object a completely new meaning.
- Form and colour are inseparable. Colour influences the perception of form, form influences the perception of colour. Choosing the right relation is the responsibility of the designer.
- A product that can change colour will keep the user excited for longer.
- Clashing colours can attract attention and be fascinating. A designer must be constantly open to new sources of inspiration.
- Many groups of products have adopted a similar colour palette for many years. Breaking this stereotype, combined with innovative design features, could be a milestone that changes the entire sector.
- Experiencing colour is completely dependent on its physical, visual and artistic context. This makes it unpredictable and at the same time extremely fascinating.

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Color Communication in Home Interior Design: and analysis of Architectural Digest covers from the 1980s, 1990s and 2000s.

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Abstract
This article intends to analyze how colors were communicated, within domestic interior desing, through the covers of Architectural Digest publications, in the United States, aiming to understand the parameters that affect color, such as its hue, luminosiry and saturation, in a way that conquests a deeper analysis of such characteristics. The analysis was made through the covers of magazines from the 1980, 1990 and 2000s and made it possible to observe how this visual communication was carried out and implemented within the concept of interior design. A review of the literature was carried out, understanding of fundamental concepts and, finally, the experiment, thus generation a new knowledge of the application of colors in domestic interiors, in the context of worldwide magazines.
Keywords: Light and color and their applications, Interior Design, Color communication in interior design

Introduction

Color is present in domestic interior spaces in the most different ways, from the elements that are placed in it as adornments, even the colors used on its walls and floors.
According to Rambauske (2015) this same color can be understood as a sensation that is transmitted through the eyes through luminous fluxes present in the objects or area of analysis, thus being able to understand that the color is actually seen by the brain, as it performs all the its interpretation.
The communication given in magazines is directly related to the composition of the colors that are defined to be present there, since each element can generate different sensations, stimulating the individual in different ways.
In order to better understand how the composition of the domestic space occurs through colors, a literature review was carried out in order to explain how the composition of this space, the colors and the parameters of analysis take place.

Literature Review

Interior Design and the Inhabited Space

The domestic environment has the function of inhabiting, sheltering people, and may have different organizations and divisions between them, but always seeking to guarantee shelter for different climatic conditions, thus giving the feeling of protection.
Le Corbusier's statement, that the house is a machine for living, can convey the idea that it should only exercise its functional idea, without any adornments being implemented, giving the idea of a dehumanization of the domestic space, which is not the that is sought when composing this space, as it is intended to create a comfortable and cozy space (Sbarra, 2013). In this way, it can be said that the house must be composed of everything that is necessary for the well-being of its occupant.
Taking the domestic environment and its composition as a starting point, it is also important to highlight their relationship and emotional connection, connecting the individual to the space. It is a place where convictions and memories are formed, as well as experiences and memories.
It is in the home that the individual has the intimate, personal and social space and through it it is possible to live emotions, share moments, build a personal identity within a common family environment, with a sense of belonging and synesthetic connection, where these emotions are

reflections of the personal experiences, associations and memories of individuals (Norman, 2004). Therefore, Guimarães (2014) states:

> Home can be the place where people go to sleep, use the bathroom or eat. Where there is a hurry to leave and the time to return is delayed. Home is the place where family members yearn to be there, where they rebuild their energies, feed on affection and find the comfort of welcoming. It is where you are in a hurry to arrive and delay the time to leave. (Guimarães, 2014)

In this way, the importance of interior design is perceived with regard to the design not only of a house, but of a home, where connections are generated at emotional levels, having meaning and importance for the user so that in this way the spaces , whether intimate, service or social, can, together, help the user's comfort.

The Use of Color in Interior Design

Active in the most diverse spheres of human life, color can be understood as a sensation based on light - which acts as a stimulus - and the eye - receptor that deciphers the luminous flux, altering or decomposing it through the selector function of the light. retina (Rambauske, 2015). Therefore, the color that is seen is actually felt and this sense is translated by the brain through the retina. Johannes Itten (2004) corroborates this sentence when he states:

> Each color in the spectrum has a wavelength; the indication of its wavelength or the number of its variations makes it possible to determine it precisely. Light waves are colorless. Color is born only in our eyes or in our brain. (Itten, 2004, p.17)

However, color is not only generated by a sensation, but is also felt through emotions and when applied to domestic interior design, its strong influence is perceived in terms of sociability, introversion and well-being, such as, for example, Light colors tend to give the illusion that the environment is bigger than it really is, and the opposite occurs with dark tones, and that's why it's so important that their application is done properly, as it changes the sensations of the environment.

From the moment that a certain color is applied in an environment, one must question whether it meets the objectives set for it, that is, if it fits in terms of aesthetics, ergonomics, application on the surface, level of brightness, visual relationship. with other colors, in addition to lighting (Pernão, 2017). Thus, the need for attention in the application of color in domestic interior design is evident, as it needs to achieve an adequate interaction with the environment in which it is inserted, so that it can be one more element in the achievement of environmental comfort, in a way that that favors the establishment of the user's self-image, as well as the feeling that that is their place in the world (Norman, 2004).

However, many of the contemporary interiors are composed by the white color in a false illusion of cleanliness and minimalism, however when this is done in the domestic interior, the interior designer ends up limiting, or even preventing, the stimuli that could occur in the environment due to the lack of color-person interaction (Pernão, 2017). It is then perceived the relevance of the application of colors in internal environments, especially in the domestic environment, since they interact with the user generating sensations and emotions, fundamental elements in the construction of environmental comfort.

Color Analysis Parameters

Desiring to expose the best way to analyze the images that make up the covers of the magazines and will be analyzed, some parameters were defined, already mentioned in the literature, in order to facilitate such application of knowledge. Therefore, an explanatory table of such parameters and what will be addressed in each of them is presented below:

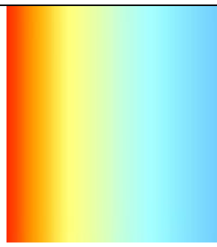
Hue	**Value, Brightness or Brightness**	**Saturation or Chroma**	**Temperature**
It represents the color itself, that is, they are the gradations that exist in the chromatic cycle and that make it possible to differentiate one color from another in visual terms.	t is related to its ability to reflect in white light. Therefore, when a color tends towards the darker or more intense side, its lightness is reduced and when the color tends towards the lighter side, its lightness is in evidence.	It refers to the intensity and vividness of a color and its degree of purity in relation to neutral gray. A color is considered saturated when it is stronger, more vivid, and unsaturated when it is grayer or duller.	Cold colors are associated with the eagle, the sky, trees and ice. They convey a feeling of cold and calm. Warm colors are associated with the sun and fire.
			

Table 3 – Definition of Hue, Value and Saturation with Images.

However, for this article, the analysis will be applied only to what concerns the color temperature present in the compositions of domestic interiors.

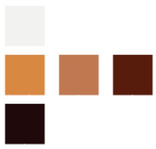
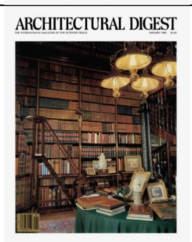
Experiment

Based on the understanding of what is the domestic interior space and the use of color, it will be analyzed, through its parameters, what is the color temperature present on the covers of Architectural Digest magazines.

It is also important to highlight that only magazines were selected that had images on their cover that make references to domestic interior design, since these are part of the object of study of this article.

The decades chosen were 1980, 1990 and 2000 and it is expected to analyze cover by cover in order to understand the functioning of society and the way it behaved when composing domestic spaces.

Thus, below is a table referring to the covers of the catalogs from the 80s:

MAGAZINE COVER	**YEAR**	**PREDOMINENT TEMPERATURE**	**COLOR PALLET**
 	1980	COLD	
 	1981	COLD	

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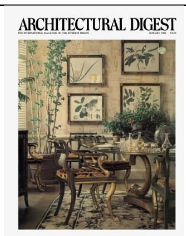
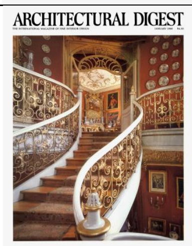
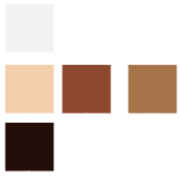
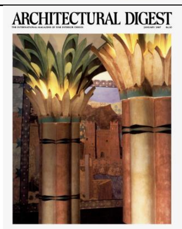
	1982	COLD	
	1983	COLD	
	1984	COLD	
	1985	COLD	
	1986	COLD	
	1987	WARM	
	1988	WARM	

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	1989	COLD	

Table 2 – Covers from 1980, 1981, 1982,1983, 1984, 1985, 1986, 1987, 1988 and 1989.

From the classification according to the divisions exposed in this table, it can be seen that the 1980s, according to the analyzed covers, have a predominance of environments consisting of colors and cold tones, with a greater presence of shades such as brown, beige and gray scale. .
It can also be seen that the spaces portrayed denote a more welcoming and intimate atmosphere, creating comfortable and conducive environments for relaxation.
As for the 1990s, the table follows:

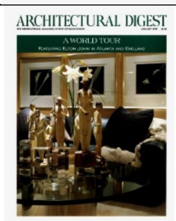
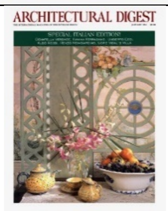
MAGAZINE COVER	YEAR	PREDOMINENT TEMPERATURE	COLOR PALLET
	1990	WARM	
	1993	COLD	
	1994	COLD	
	1996	WARM	

Table 3 – Covers from 1990, 1993, 1994 and 1996.

The graphic representations of interior spaces from 1990 already show a certain similarity in their composition, thus presenting warm and cold interior environments, which alternate in relation to the years.
It is noticed that the environments of greater interaction, such as the living rooms and the dining room, are presented with compositions of warm colors, being more appropriate for the activities that will be developed there.
As for the 2000s, the table follows:

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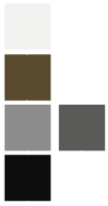
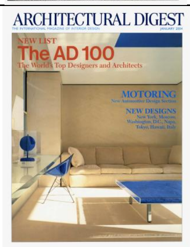
COVER MAGAZINE	YEAR	PREDOMINENT TEMPERATURE	COLOR PALLET
	2000	COLD	
	2001	COLD	
	2002	COLD	
	2004	COLD	
	2005	COLD	
	2006	COLD	

Table 4 – Covers from 2000, 2001, 2002, 2004, 2005 and 2006.

Conclusions

In view of the elements exposed through the tables under analysis, it is possible to perceive the influence of colors in interior environments and their relevance when applied in domestic environments.

About the 1980s, he realizes that his composition is predominantly cold, with pastel tones and the presence of gray scales, however, even so, he presents harmony in his composition.

In the 1990s, the existing duality is perceptible, since four magazines were analyzed and their interiors were divided evenly, thus creating environments with warm and cold tones.

The 2000s were marked by the predominance of cold tones, also with the presence of shades in blue, green, grayscale and beige.

Thus, it can be said that the environments presented through the covers of Architectural Digest have predominantly cold tones in their composition and design of space.

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Color and light in the photography of contemporary architecture.

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Abstract
This paper studied color and their distribution through photography of architectural projects designed by the most influential and contemporary architects of lighting design. The main objective of the research is to understand the contemporary design and aesthetic principals using color and light as symbols of change and innovation throw official published photography. The methodology of the research was conducted by three complementary steps : firstly, the choice of representative projects designed with light as principal design palette; the chosen projects are contained in the book by the famous architecture photographer Peter HYATT entitled Masters of Light. Second step was the data collection; by visiting the official website of each architect to obtain the photos published for each project. Third step was the evaluation of color distribution using computer simulation via specific software of color-analysis to obtain RGB-diagrams and matrix-images of each photo; the objective is to identify the dominant color for every photography. The results allow the elaboration of recommended color range map for architectural photography which can be adopted during the early steps of lighting design to ensure the success of visual perception of the published photography. The main objective of this research is to take a step in understanding the characteristics of architectural photography in order to decipher it.

Keywords: architectural photography, lighting design, color coding, visual perception.

Introduction

Architecture and photography are two closely related disciplines whose interaction has evolved considerably over the time. (Lepere, 2018) The photographic act has become an instrument of representation increasingly used in architecture, it has given a boost to its popularity by playing a very important role in its dissemination, transmission and exhibition until becoming an essential means for communicating it. (Schulz, 2015) (La Cova, 2019). For its part, the context of architectural production has undergone an unprecedented revival and profound transformations consequence of several factors : technological inventions and the development of the Internet among the general public which has favored among other thing and the dissemination of architectural information often accompanied by photographs or digital images. (Leda, 2020) Moreover, architectural agencies are increasingly calling on professional photographers to produce views staging their projects, making them a machines to seduce the public. (Pacot, 2020) Architects rely on photographic images to convey a message or legitimize their work. (Pelizzari & Scrivano, 2011) Photography becomes a reference tool, and constitutes one of the basic components of the creative process. Movement, colors, lines of composition, atmospheres, textures and other space components constitute a data which can lead to being translated architecturally and spatially by following a precise approach. (Lepere, 2018) (Schwarzer, 2017). For its part, in the contexte of contemporary architecture, light as a term that is moreover employee on the common language of contemporary architects, landscape architects and town planners, seems to have a great success thanks to its transversal and interdisciplinary character allowing to combine environmental control, sensitive experience and pay attention to usage. (Chadoin, 2010). (Söderström, 2019).

2. State of the art

2.1. Architecture as a separate art

Vitruvius defines architecture as an art of drawing by announcing that "*Architecture is a Science accompanied by a great diversity of studies and knowledge*".(Guidi, 2014) (Tardieur, 1937) In his live "Précis des architectural lessons" published in 1802, Durant pointed out the special character of architecture as "*an art apart*" and described the means that every architect must use to carry out a construction project (Durant, 1805). John Christopher Jones prophesies a third way by announcing the "reflective" models of design with three postures : the designer-magician (black box), the designer-computer (glass box) and the designer-self-organized (the context of emergence of knowledge). (Schon, 1984).

2.2. Architectural photography as a new artistic genre

Architectural photography seems to have had a different history than photography in general. (Pacot, 2020) The advent of photography in the 19th century introduced a change in the visual representation of the built world. At the start of the 20th century, the Bauhaus movement founded by Walter Gropius began to view photography as an "applied art": an ideal combination of craftsmanship and artistic expression. (Pelizzari & Scrivano, 2011). A complete turning point with the postmodern debate introducing a change in contemporary practices and encouraging architects to think more and more "photographically". (Olivares, 2010). New camera technology has added previously additional information to the architectural domain. (Schwarzer, 2017). Quickly, architectural photographs gained prominence and featured prominently in architectural production. (Schutz, 2015). It is thanks to photography that the buildings are transmitted to the world knowledge. It serves to promote architecture and to disseminate it globally in books, magazines, catalogs, the Internet, through images that are constantly scattered and published. (Lopuska, 2012).

2.3. Light to reinvent architecture

Light constantly renews the tremendous potential it offers to reinvent architecture. (Khosravi, 2014). More and more architects are keen to reveal the spaces they design by projecting the luminous atmosphere that they wish to bring to life for the future users of the building. (Drozd, 2015). Many architects, landscape and urban planners rely on light and use new tools for their projects, allowing them to combine environmental control, sensitive experience and attention to users. (Chadoin, 2010). The notion of luminous ambience articulates the technical and aesthetic aspects of the built environments. (Daiche, 2016). By circumventing the principles of an architecture perceived as visual object, the luminous ambience is then placed as an attempt to go beyond architectural object to partially redraw the criteria for evaluating building production. (Daniel Siret, Olivier Balaÿ, 2004).

2.4. Internet for global accessibility to architecture

The last decade of the 20th century was marked by the invention of the World Wide Web; an information exchange system in the form of virtual pages. (Leda, 2020) This period therefore has the advantage of experiencing a great development of representation ways in architecture by their massive dissemination. Moreover, from the beginning of the 21st century, the architectural photography contribute to the notoriety of the architect because they are no longer remain internal to the creative process, but play a new role of mediation between the architect and large lay and professional public. Publication via the Internet therefore appears as a new category of completely fundamental representative image of the project with the same importance as the traditional plans, sections and facades. (Drozd, 2011)

3. Methodology

This research combines quantitative and qualitative methodology to study respectively color and light throw photography. The choice to focus on the photography of the building was argued by two reasons : architects never feel betrayed by letting their photography talking and the today's architects projetcs and design principals is to be extracted from their own websites as well as through related research to their work.

3.1. Data collection and analysis

The book "Masters of Light" by the famous writer and architectural photographer Peter HYATT was choosen as reference book. It condenses the knowledge and secrets of fifteen architects considered as masters of lighting design in a new approach to contemporary architecture. A first exploration was carried out on the basis of the information presented in the book, and supplemented by a visit to the official website of each architect. 25 projects have emerged and will represent our study corpus:

N°	Project	Architect	Year	City	Country
01	20x20 House	Felipe Assadi	2005	Santiago	Chile
02	Casa Raveau	Felipe Assadi	2006	Santiago	Chile
03	Casa Schmitz	Felipe Assadi	2001	Santiago	Chile
04	Casa Serrano	Felipe Assadi	2006	Santiago	Chile
05	Glass Shutter House	Shigeru Ban	2003	Tokyo	Japan
06	Naked House	Shigeru Ban	2000	Saitama	Japan
07	Picture Window House	Shigeru Ban	2002	Shizuoka	Japan
08	Arkansas House	Marlon Blackwell	2004	Arkansas	USA
09	Keenan Tower House	Marlon Blackwell	2000	Arkansas	USA
10	Asencio House	Alberto Campo Baeza	2000	Cadix	Spain
11	Holman Residence	Durbach Block	2004	Sydney	Australia
12	Spry Residence	Durbach Block	2003	Sydney	Australia
13	Guesthouse	Kanner Architects	2006	Californie	USA
14	Malibu 3	Kanner Architects	2004	Californie	USA
15	Butterfly House	Lippmann Associates	2005	Sydney	Australia
16	Pearl Beach House	Lippmann Associates	2007	Sydney	Australia
17	Dirk Cove House	Niall McLaughlin	2004	Cork, Ireland	UK
18	Balmoral House	Ian Moore Architects	2006	Sydney	Australia
19	Chicken Point Cabin	Olson Kundig	2003	Idaho	USA
20	Cell Brick House	Atelier Tekuto	2004	Tokyo	Japan
21	Lucky Drops House	Atelier Tekuto	2005	Tokyo	Japan
22	Engawa House	Tezuka Architects	2003	Tokyo	Japan
23	Machiya House	Tezuka Architects	2000	Tokyo	Japan
24	Casa D'Agua	Isay Weinfeld	2003	Sao Paulo	Brazil
25	Casa Inglaterra	Isay Weinfeld	2000	Sao Paulo	Brazil

Tab. 1 - List of projects representing the study corpus.

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3.2. Presentation of the final Corpus

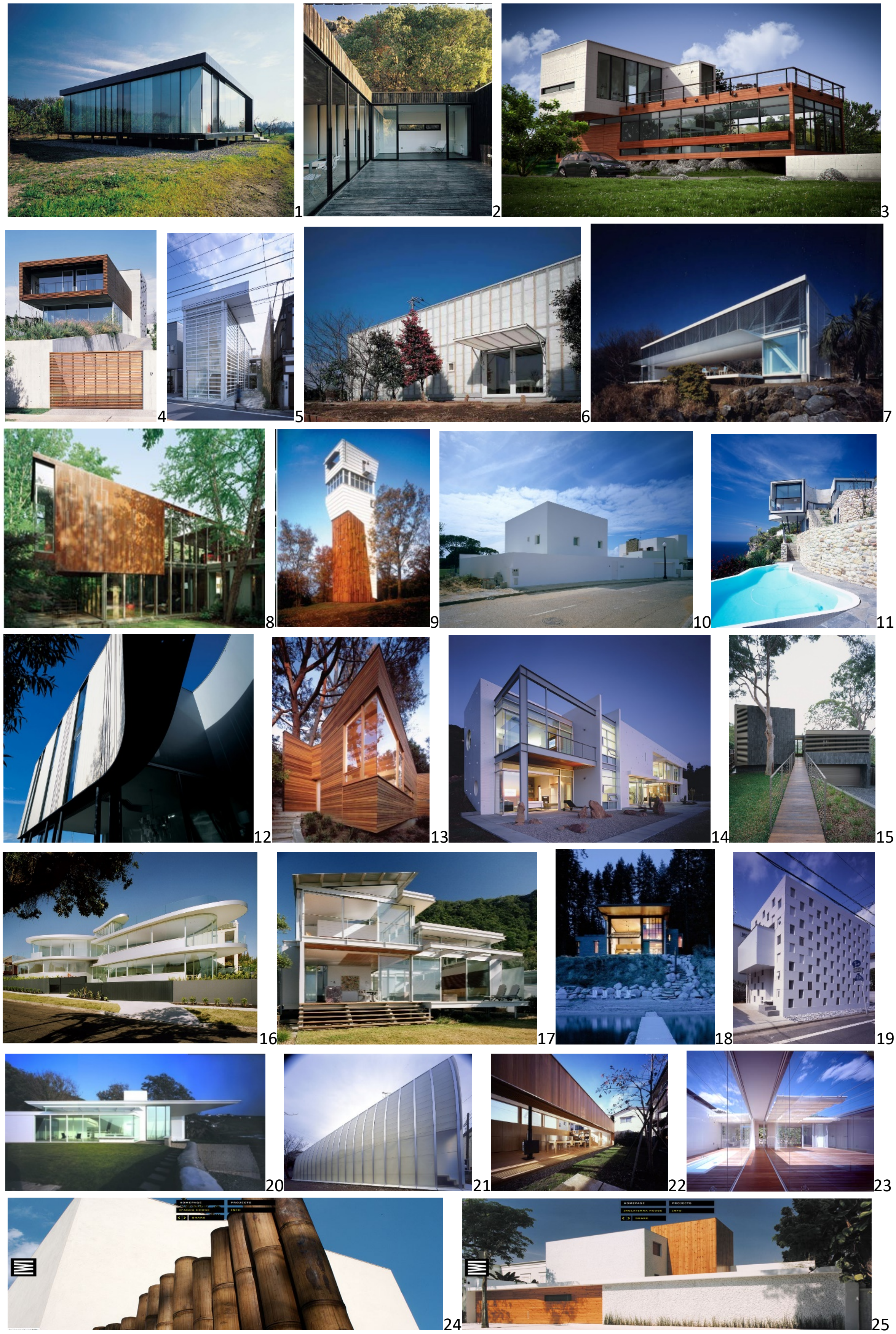

Fig. 1 - Photos de l'extérieur

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4. Résultats & discutions

4.1. Color coding

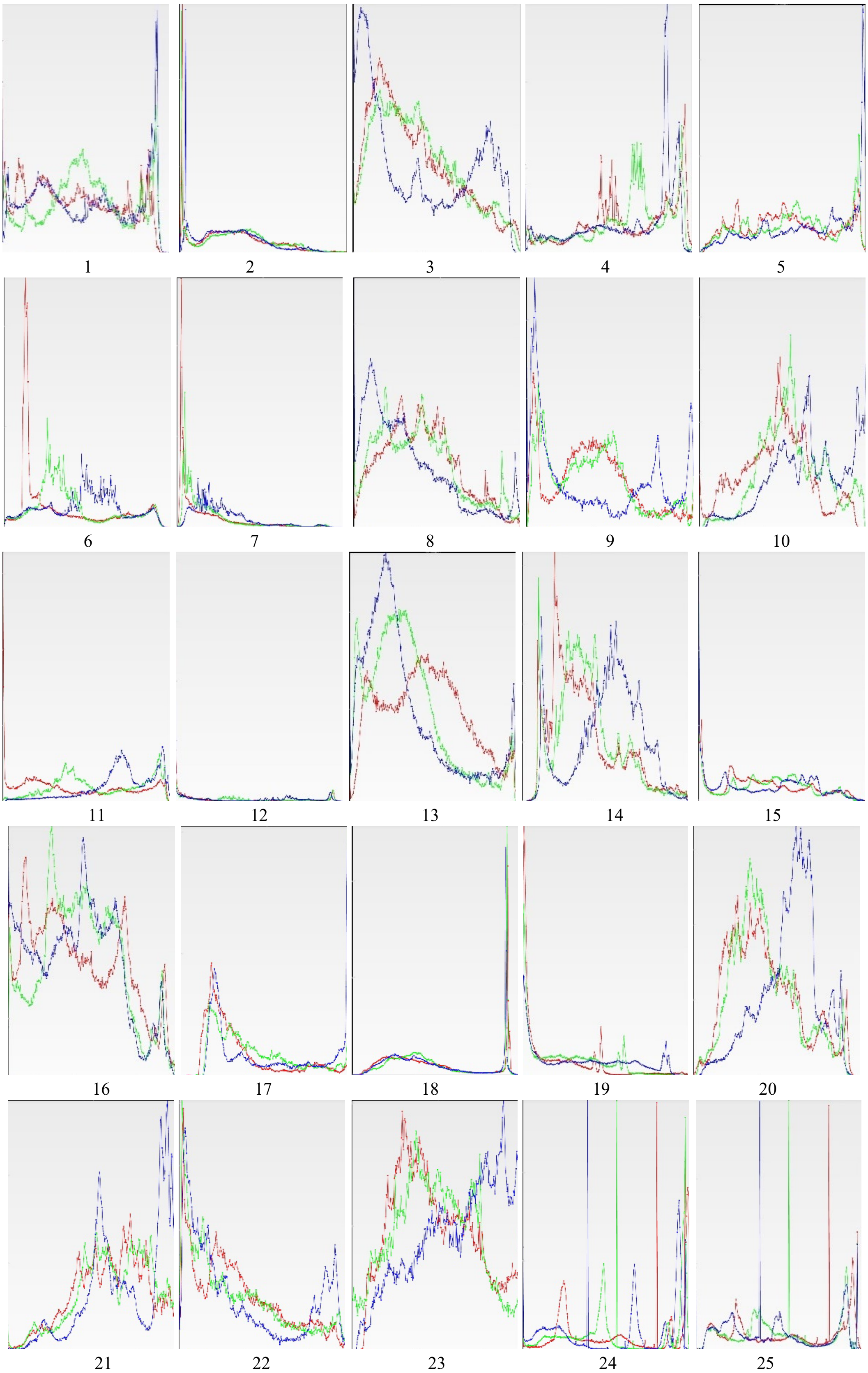

Fig. 2 - RGB diagrams

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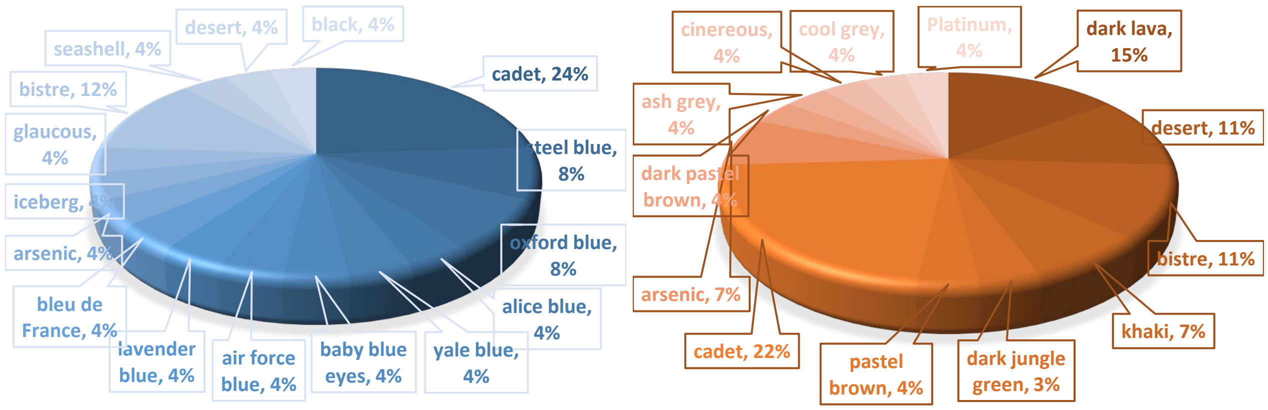

Fig. 3 – Graph in the left : building exerior - Graph in the right : inerior space

4.2. Interpretation

a) The photography featuring the exterior surfaces of buildings :

- Color caracteristics : dominance of the "Cyan-Blue" color group with 76% composed of twelve colors, namely: cadet, steel blue, oxford blue, alice blue, yale blue, baby blue eyes, air force blue, lavender blue, bleu de France, arsenic, iceberg, glaucous. The second color group is “orange and brown” 20% as a result of the enhancement of the natural environment represented by the greenery around the building.

- Light appearance : the dominance of "Cyan-Blue" color group in the analyzed photos is the result of the presence of clear sky without sun in all the photos featuring the outdoor luminous environment. Although the perceiving subject does not see the sun, but, the exterior surfaces of the building are composed of a rhythm of sunlight and shadow highlighting the architectural elements of the building.

b) The photography featuring the interior space of buildings :

- Color caracteristics : the dominant color group is “Orange & brown” with 52% composed of six colors, namely: dark lava, desert, bistre, khaki, dark jungle green, pastel brown. The second dominant color group is "Cyan-Blue" composed of two colors, namely: cadet and arsenic.

- Light appearance : natural light is present in all the photos with a sunspot in the middle of the space photo and the shadow of the furniture on the floor. The dominance of "Orange & brown" color group in the analyzed photos is the result of the use of parquet on the floor. The “cyan-blue” color group is also present in the interior photos as a result of the views from the window showing part of the sky outside encouraged by its reflection on the white walls and ceiling.

Conclusions

This study confirms that architectural photography is increasingly used as an undeniable tool for the representation of the architectural project. In addition, color and light are used by the comtemporary architects with care and precision to highlight their design solutions and their aesthetic principals. The clear sky as essential source of luminance for both outdoor and indoor the building, the enhancement of the interior design by adopting shadow and sunspot highlighting the shape of the space and the interior furniture. This research constitutes a step in a long path of updating knowledge towards the use of light and color as design tools at the service of the architect and responding to the visual comfort of the viewer.

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The Colours of Sustainability: how materials CMF Design can guide sustainable perceptions and behaviours

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Abstract
The growing interest in sustainable production is a trend driven by increased awareness of the need for a change in today's way of designing, producing, consuming, and living. Thanks to renovated attention, different materials have been developed from a sustainable perspective, from natural to recycled, compostable and recyclable resources. The material's origin, intrinsic qualities and the processes used often give them unique sensory attributes but with aesthetic identities not always coherent about their sustainability implications. In designing their functional, sensory, and aesthetic characteristics, sustainable products and materials must find their own identity according to their potential life cycle.
As a multidisciplinary mediator, the designer can evaluate materials and product optimal life cycle, set functional and aesthetical criteria, select materials and suppliers, optimize processes, and keep attention to design materials aspects as a means of communication. CMF design can support aesthetic-sensorial thinking to model sustainable products in the materials and design sector. Colour represents a key element: together with material and finish can lead to defining the aesthetic and sensory qualities supporting a sustainable identity, perceptions, and behaviours. This paper will explore CMF as a tool for "materials design" with a close look at the colour and how it can drive sustainable perception in today's heterogeneous and complex emerging materials context. Boundaries and guidelines for the use of colour will be applied according to materials' life cycle (source, processes, user and context, end of life) to generate greater awareness for designers wishing to select, design or apply sustainable materials in design projects.

Keywords: CMF Design, sustainable colors, sustainable design, aesthetic, perception, behavioral design.

Introduction

The concept of the industrial designer was born around 1920 when the need to make products more attractive on the market through new shapes and decoration began to emerge (Dobers and Strannegård, 2005). The figure of the designer grew increasingly, becoming a point of reference for companies and acquiring more and more technical skills. In the 1980s, product offerings focused no longer on the purely technical and aesthetic aspect but on what the artefact communicated: lifestyle. Over the years, consumption increasingly concentrated on the immaterial dimension of the product, becoming an 'experience' in the 21st century (Gardien, 2014). However, this model based on sales and aggressive marketing that encourages constant product launches, favouring a continuous turnover of products, is no longer a viable path. The climate emergency we are experiencing only partly contributes to the construction of ecological and sustainable thinking (Kong *et al.*,2014).
It's complicated to define the 'sustainability' of a product because this cannot be measured through a single parameter but with many parameters on different layers (Wilkes, 2016). Therefore, since it is not universally measurable, it cannot be communicated effectively except by resorting to banalisation that minimises sustainability itself.

The average consumer, unconscious of the issue's complexity, can't fully understand the meaning and possibilities that a sustainable product should have and therefore tends to belittle and undervalue products that could have less impact on the planet. This fact often happens because, compared to traditional products, sustainable ones are not perceived as durable and performing. So, consumers tend to prefer traditional ones because they can understand and appreciate them as a consumption habit.

Therefore, the attention to the product's environmental impact is significant, and the appearance will gain increasing importance since it arouses emotions in the consumer and has consequences on the market. The consumer's choice happens quickly on average and is entrusted more to instinct. The exploited sense, and lately also abused, is sight. Indeed, we live in a society of images. Through our eyes, we understand and absorb the world around us (Locher *et. al.*, 2010). The sight sense allows us to orient ourselves in the world as human beings and ensures our survival. Just think how just looking at the fruit, we can decide whether it's edible or not: we can judge object properties through the knowledge we create during our lives. Observing a product, it is possible to make an initial assessment of its physical characteristics: imagine the sensation it can give us when we touch it and hypothesise its heaviness and sound (Fleming, 2014). Sight, therefore, allows us to have a global perception of the physical properties of an object and consequently also of the material: its colour, texture, transparency, glossiness, etc. A general principle of aesthetic pleasure derived from sight lies in symmetry, unity, proportion, complexity and colour.

The aesthetic of sustainability

The trend towards more sustainable consumption links to the need to succeed in constructing an aesthetics of sustainability: an implicit language that can communicate the sustainable value of a material or product. Today we see on the market several attempts to communicate the philosophy of the product through material or communication choices. Thanks to a renovated sensibility, on the market is possible to find sustainable materials from natural and recycled resources, from waste or by-products. Because of their origin and processes used these materials are often characterized by unique sensory qualities.

The Swedish government declared as early as the beginning of 2005: "Products and artifacts should be designed in a sustainable way and with an aesthetic that contributes to that we use them for longer time periods in our households" (SOU2005:51, 2005). Aesthetic is thus acquiring a crucial role in raising consumer awareness and steering sustainable behaviours. Zafarmand (Zafarmand *et al.*, 2003) has made a significant contribution to the search for an aesthetic of sustainability, coming up with seven main aesthetic attributes that can promote a sustainable product.

Aesthetic durability - This aspect emphasises the importance of achieving an aesthetic finish that does not compromise its beauty over time. So, the design considers the change in colour over time (e.g., objects made of polymeric material) and enhances the variation. The attention to the passage of time with appropriate design could increase the object value by creating an emotional bond between the artefact and the user.

Aesthetic upgrade-ability and modularity - Modular design offers the possibility to upgrade and replace certain parts of one's product. In this case, the colour can become a characterising element, allowing to change the product's appearance without replacing it. Modular design allows a product to be used for longer, saving resources and energy.

Simplicity and minimalism - When designing a sustainable product, it is essential to follow the principles of 'Design for Simplicity', emphasising the minimal use of material and composition that allows easy disassembly. However, this choice couldn't cause oversimplification in the user's eyes but must remain valuable. In this case, the colours and finishes selection could become fundamental to succeed in giving to a simple product the right aura of preciousness, creating emotion and empathy between user and product.

Logicality and functionality - Being able to guide the user to the correct use of the product not only allows positive interaction but also prolongs the object's life since it is not misused. Colour can lead to proper usage through a language that creates a durable and functional aesthetic.
Natural forms and materials (naturalness) - The design of a sustainable product should be inspired by nature since 'in nature, forms and materials are perfectly fitted to the functions and everything has a permanent dynamic aesthetic'. The natural forms' use, materials and colours can strengthen the relationship between user and product. So, the public it's increasingly environmentally aware and able to reconnect with the harmony of nature.
Local aesthetic and cultural identity - Sustainability also involves an ethical and social dimension. Designing to enhance locality and cultural identity allows us to create products that reflect the values of a community and are imperishable. The use of patterns and colours characteristic of certain cultures are timeless and strengthen the bond with the territory.
Individuality and diversity - A sustainable product respects people's individuality, aesthetic tastes and diversity. Designing flexible, modular and easily adaptable artefacts allow for greater product attachment and longer use than the traditional ones. Colour and visual textures can easily differentiate products, making them suitable for different communities and cultures without creating new pieces and artefacts, investing materials and energy.
Therefore, due to the complexity of defining a sustainable aesthetic: a single answer cannot be the solution. Indeed, as Sarah Wilkes et al. (2016) argue: the perceived sustainability of a material cannot be reduced to a set of measurable physical properties, nor can it simply be attributed to cultural preconceptions. The sustainability of a material depends on our criteria and how we perceive the problems. These vary not only over time but also for community and education.

CMF Design

Design CMF stands for Colour, Material and Finish. The term, coined in the 1980s by Clinio Trini Castelli, has become an indicator of a discipline that, over the years, has involved more and more designers and professionals (Lucibello, 2005). Starting in the 1980s/90s, with the development of an experiential type of consumption that aimed to diversify the offer using eclectic, dynamic and ornamental aesthetics (Gardien, 2014), CMF design has made it possible to diversify the offer by adapting it to the different needs of the market. The first example of "Material Design" in design culture has been "Neolite" (Manzini and Petrillo, 1991), which was the adventurous heterogeneous plastic recycled in search of an "own identity". From here came the concept of materials soft qualities design to determine materials identity and the subject of material design intersects for the first time directly with the theme of sustainability. In CMF design, it is indeed important to respect not only the project's own requirements, but those of society. The dichotomy between technical and anthropological aspects is peculiar to this discipline since it also appeals to emotional and socio-cultural elements (Becerra, 2016). The CMF analysis links to trends reflecting the societies of the moment of a given time and place, customs, colours and traditions. CMF design tools and methodologies have become an integral part of the design, especially in sectors with a very high complexity level in scale and detail, such as in the world of sports and automotive. The CMF design process progresses with several steps, from defining the context and personas to defining a CMF strategy, dividing up the parts and constructing explanatory mood boards of the project in all its details.
This discipline allows each constituent detail of the product to be analysed and kept under control in its colour, material and finish. The possibility of checking and simultaneously having an overall view of the product provides value to the artefacts by balancing the technical, aesthetic, and functional aspects (Becerra, 2016). The product value, usability, appeal, and the user's attachment are all features passing through the perception of the artefact, and thus CMF design elements.
The material is the essence of the product, and its selection has always been relevant in defining the product itself. Through the material, the designer determines the form, but also its processability and consequently its cost. On the other hand, the finish, very often taken for granted, is the point

where the user encounters the artefact, expanding the sensorial relationship begun through sight. The outermost surface can communicate sensations of hot, cold, rough, smooth, etc., sometimes creating surprise in those who touch or interact with the product for the first time (Del Curto *et al.*, 2010). But among the CMF elements, colour firstly captures the consumer's attention and initiates cognition. Colour is the first element we perceive, and according to E. Bullough (1880-1934), the human reaction to colour can be of three types: objective type, preference for a specific kind of colour; associative type, appreciate or not colours relating to aroused sensations; psychological type, the association between colours and taste, like green for nature-like trends.
But colour has not only the function of the first element of interaction. As already indicated above, it becomes a significant element not only for the perception and emotions it arouses towards a product but also for more technical and functional aspects: usability, performance, value, ability to adapt to the passage of time, and interaction with the user.

Sustainable perception

In reflecting on perceptions of sustainability, various research has been carried out concerning consumer relations and correlating objects with definitions of quality and naturalness. Achieving this is an ambitious objective since materials' soft qualities are complex to correlate to physical parameters (Figuerola et al., 2016) and even more with intangible meanings as sustainability is.
In the first study, Petersen and Brokhaus (2017) investigated consumer attitudes towards two versions of music headphones and rubbish bags. The two product typologies featured a version made of traditional material and a 'green' version characterised by natural/pastel colours and irregular visual texture. In both cases, it was evident how the aesthetic appearance of the products influenced the overall perception of the object. The natural colours, along with the imperfection-creating textures, lead the consumer to assume that the product is more environmentally sustainable. But while these features enhance the perception of sustainability, they also diminish the perception of quality and performance of the product itself.
Elvin Karana, on the other hand, allowed its panelists to choose objects or materials that reflected the concepts of 'natural' and 'high quality' (Karana, 2012). Thirty products were collected for each attribute and then analysed according to material properties, product appearance, the context of use and intangible aspects (mood, culture, values, emotions). The analysis showed that the two attributes are opposites in many aspects. Analysing the products attributed to 'natural', it emerged how natural colours in shades of brown/beige, visible fibres and grains, and imperfections are discriminating factors in the product choice since they confer uniqueness. In addition, warmer, rougher, and heavier materials are considered more authentic and natural.
In contrast, the 30 products that correspond to 'high quality' are characterised by cold, neutral colours veering between white, black, and silver. These refer to qualities like elegant, serious, chic, and masculine and reflect a clean, strong, and durable condition. Moreover, lightness, unlike 'natural' materials, would communicate the guarantee of high performance.
Therefore, starting from these considerations, it is not difficult to analyze the current scenario and imagine how the consumer's sensitivity is changing, and how color as a primary aesthetic attribute is today used as a lever in products to guide certain perceptions and behaviors.
In a study conducted by the authors (Sossini, 2020), the perception of different products and materials aesthetic was analysed, asking to 135 interviewed to choose the most sustainable relating to the visual perception. In the first group (Fig. 1), according to the sample interviewed, the two recognized as sustainable products are seats 2 and 3. From the picture, it's clear that the two seats fully reflect the characteristics illustrated by Karana (Karana, 2012): natural colours, imperfections and visible inclusions. However, the most remarkable part of this survey was that all the presented materials could be considered 'sustainable' in different ways since they were all bioplastics, recycled or composites with bio-based resins.

Fig. 1 – First group of analysed products

The second group of provided (Fig. 2) were images of materials samples. Again, all the materials were bioplastics or bio-based resins with fibres, except for number 3: a recycled fossil-based plastic. In this set of images, as the product architecture wasn't clear, it was more complicated for interviewed to judge the sustainable aspect. The sustainable-like material was material 4, with earthy colour, a rough and irregular surface and colouring. After material number 4, there are the number 5, composite with natural-coloured fibres; recycled material 3 with coloured inclusions that communicate the clear fossil-origin; material 1, linked to the milky and translucent colours, related to the now established use of PLA; material 6 with more traditional plastic colours; and finally material 2, which, due to its brilliance and iridescence, can't be associated to a natural material such as cellulose (of which it is made).

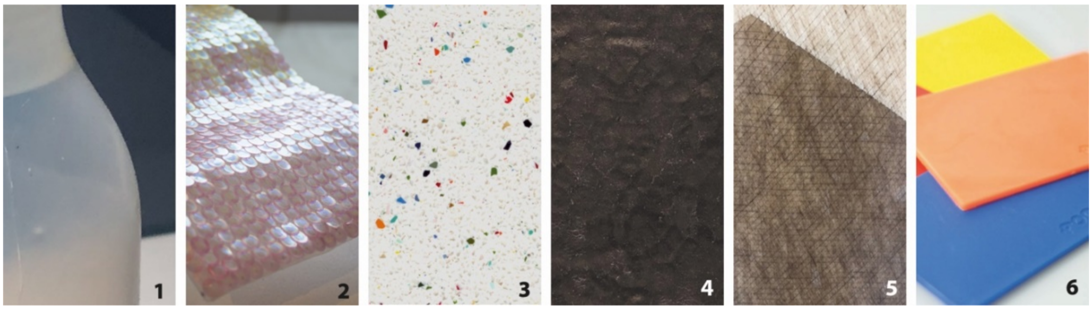

Fig. 2 – Second group of analysed materials

Therefore, it's possible to identify two distinct ways in which sustainable materials can present themselves on the market: by flaunting their 'imperfect' and irregular origin; or by imitating a traditional natural material while completely concealing their source. The former exploits natural colours ranging from brown and beige shades to green ones with irregular, matt finishes. On the other hand, when they conceal their origin, they draw on traditional materials, favouring brighter colours without irregularities, or whites and blacks, transparencies, and glossy finishes.

However, neither approach seems to communicate effectively with the consumer. Materials that express their naturalness, in fact, place a strong emphasis on green aesthetics, which may not always be appreciated, because they are often linked to low-quality but high-cost concepts. Conversely, materials that hide their natural origin do not clearly convey the difference from conventional materials. In both cases, the result is that material appreciation is limited to niche user groups in societies.

Sustainable behaviour

The designer, as a multidisciplinary mediator, should guide the consumer towards the correct use of a product and mid-long term sustainable behaviours. Good design involves the abilities to respect the environment and the use of resources at all production and use stages, to share and communicate values with consumers, and to raise awareness and educate. Being able to design for sustainable behaviour through materials means guiding consumers to different roads: reduce resource consumption, maintain, and adapt their product to the passage of time, optimize product use, etc.

Of course, the change must follow the product effectively sustainability in the different use scenarios (Santi, 2021).
In this case, the aesthetic of sustainability, seen above with Zafarmand (2003), acquires an intentional objective, powerful and rich of ethical considerations. The material use in a product must be evaluated through sustainability metrics varying the possible use scenarios. And according to best one, the correct aesthetic should be considered.
The first behaviour that a material can steer is the attractive one, causing purchase: communicating properly, using colours, materials, finishes and shapes to arouse a positive emotion in the buyer is fundamental when dealing with conscious materials.
Moreover, materials and their aesthetics can act on the keeping behaviour extending product life, preservation over time; upgradability, which through certain modifications increases the value of the product; and reuse. Another group of behaviours, on the other hand, encourages awareness and the development of a green attitude in the consumer to guide them towards a more long-term circular lifestyle. In this sense, there is a propensity toward more sustainable product consumption, compared to traditional alternatives, energy and resource saving, and the impulse towards experimentation that can facilitate the meeting between users and materials.
Lastly, especially meant for the short-life products, a group of behaviours is related to renewability, connected to the correct disposal of products to favour recycling or the most suitable disposal.
From the analysis carried out by the authors (Santi, 2021), three different strategies for the aesthetic of bio-based and compostable materials in product sector emerged - Show, Highlight, Hide (Fig. 3) - through which aesthetics can express and guide sustainable behaviour.

Fig. 3 – Sustainable behavior strategies

Show - wishes to be honest and fair with the true nature of the materials used. In this case, the link with nature is communicated, favouring pastel, yellowish colours, milky transparencies, tiny inclusions, and rather rough, irregular, and matt surfaces avoiding additives and applied finishing layers. Organic and new forms are used to emphasise a novel use of material. The strategy should be applied to encourage proper disposal as the material tries to communicate its true nature; to raise awareness and favour the use of sustainable materials; through new forms, it could promote upgrading, finding new applications and increasing the value of the product itself.
Highlight - this strategy has an aggressive language to emphasise the imperfect nature of the products and, if necessary, communicate with expressive graphic language. In this case, the colours are still natural but darker, rougher, and very irregular due also to untraditional or craft processes. The aesthetics are reminiscent of DIY materials with raw and incomplete surfaces, natural textures, and basic shapes. In the case of composites, the fibres will be of significant size, sometimes giving a certain roughness to the surface. This aesthetic screams the origin of the material: it can allow for the proper allocation and, if necessary, even the separation between different materials. The graphical appearance could favour a non-conventional message identifying users' green attitude. The very raw nature of the product should encourage it to be kept, as the user could value the uniqueness of the material, inducing experimentation and recreating materials or objects like the one purchased by upgrading scraps and by-products.

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Hide - in this last strategy, the designer can deliberately conceal the material origin. Obscuring the real nature could favour the high-quality perception, a long-lasting user experience, and a non-disruptive purchase behaviour. Hiding the source of the material also goes through imitation, both natural and synthesised materials. Indeed, this is a recurrent and warning strategy frequent on the market with cases where bioplastics imitate traditional plastics. They should be presented with bright colours, transparencies, glossy, homogeneous colours and surfaces, with visual and tactile textures created through moulds. Alternatively, new materials imitate other naturals, creating a paradox since bioplastics or other composites often resemble stone, ceramics, or wood, even though sometimes they can be considered in this way even more 'sustainable' In this case, the aesthetic strategy should be properly studied with the product, function, evaluating sustainable usage scenarios favouring life extension behaviour, upgrades, and reuse.

As stated above, the materials aesthetic attributes are powerful mediator between product and consumer. The ethical concerns in material use must be considered. The best scenarios of behavior and use of materials and products can be evaluated by comparing them in the environmental assessment phase. Aesthetic strategies can be molded around them by continuously experimenting with the consumers' perception in a constantly changing reality.

Conclusions

The search for an aesthetic of sustainable materials is one of the crucial points for product-user relation toward sustainability. If the traditional materials have yet their own identity, the emerging one as natural and recycled acquire different appearances. Given the complexity of the subject, sustainable aesthetic identity will probably be defined in a series of numerous facets. This paper presents an early reflection on how it is moving within CMF design.

Surely, there is the example of plastic: a recent material, compared to the traditional ones, which only since the 1950s has found its own identity (Karana *et al.*, 2015). Plastics did not have the characteristics of the then-known materials, heaviness, gloss, and hardness. On the market, they tended to aesthetically imitate materials already accepted by society - such as wood and marble. It was only after Tupperware's innovation that plastics began to be appreciated for their intrinsic properties and the possibility of using bright colours. Of course, even for emerging sustainable materials, it will still take years before they are accepted and appreciated, not only for their environmental potentialities but also for their functional, sensory, and aesthetic characteristics.

Environmental demands and societal trends are moving towards new product models and a new consumer taste. Looking at their circularity, sustainable materials aesthetic can guide the user towards a new lifestyle. The designer as a mediator and generator of innovative visions should coordinate this transition, evaluating and encouraging the application of sustainable materials to raise awareness and guide the user towards behaviour that can enhance the culture of sustainability.

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Chromatic Vocabulary: the color design research according to Gianfranco Ferré

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Abstract

The study of color in the fashion design field has been much debated. From being a source of inspiration for designers, the use of color acquired an evident relevance as an element capable of defining the perceptive variations and intrinsic meanings established in the dialogic relationship between the material and its cultural dimension. Consequently, it becomes a communicative and visual vehicle of great impact, defining personal and social identities and conveying messages that address today to a larger audience.

In its relationship with matter, we can notice that color takes on a stronger semantic connotation. It is a linguistic element that, particularly in fashion, contributes to the overall narrative of creation that finds the codes of its language in the identity of the individual but also in the socio-cultural context in which it is immersed. Fashion and cultural studies have now shown that if fashion is an expression of the self, color is actually a tool for constructing a personal statement and expressing it. Therefore, color - as an expressive code and bearer of shared socio-cultural values - strongly influences the value, design and identity construction of fashion itself.

One fashion designer who has always distinguished himself for his rigorous and complex creative process in the use of color was Gianfranco Ferré. His teaching and design method was expressed through the contamination of three variables– color, shape and matter– declined in a plurality of models and formats that express desire, dream and luxury, without losing any connection with the real and material world.

For Ferré, the use of color plays a primary role, in realizing unique and irreproducible combinations of form and substance, for conveying precise feelings and emotions, enhancing the body of the wearer. For this reason, Ferré considers the choice of colors and their shades an "intentional" act born at the same time as the idea of the dress itself and that guarantees coherence and identity among seasons and collections. Due to the uniqueness of his creative process, which represents still nowadays a multifaceted material of study, this paper aims to analyze and investigate the role of color in Gianfranco Ferré's method and how it became effectively part of his lexicon. Case studies, practical examples and lectures held by the designer will show the relevance of the color and its articulation in his production, from the influence of his sources of inspiration to his iconic "white shirt" whose color justifies the existence itself of the shirt as a universal piece where tradition and innovation meet.

Keywords: color design research, Gianfranco Ferré, fashion design

Introduction

Fashion, the sociology of dress, and the semiology of clothing and their relevance in the cultural system have been deeply analyzed by researchers and academics belonging to the field of fashion studies and theory, but - as a social phenomenon worthy of social scientific inquiry (Aspers and Godart, 2013) - also to philosophy, linguistic and sociological science. The development of scholarly literature on costume history and fashion theory is largely a product of research that began in earnest in the mid-to-late 1960s (NYPL.com, 2007), in the 1970s and 1980s, then fashion studies really took off and were consolidated as a discrete field of inquiry (Mora, Rocamora and Volonté, 2014), derived from a combination of material culture studies and cultural studies (Smelik, 2017). Publications such as Dick Hebdige's *Subculture and the Meaning of Style* (1979), Elizabeth Wilson's *Adorned in Dreams: Fashion and Modernity* (1985) or Caroline Evans and Minna Thornton's *Women and Fashion: A New Look* (1989) (Mora, Rocamora and Volonté, 2014) supported the institutionalization of fashion studies. Since then, dedicated academic journals have been launched such as *Fashion Theory*, in 1997, *and Critical Studies in Fashion and Beauty*, in 2010, which represented an important moment in legitimizing the study of dress and fashion as an academic discipline (Smelik, 2017). Moreover, multi-disciplinary and interdisciplinary studies offer evaluations of dress in new contexts, such as economics, geography, cultural studies and social sciences, involving "not only economists and sociologists, social historians and cultural anthropologists, but also philosophers and moralists, poets, playwrights, and novelists" (Gregory, 1947).

One of the forerunners of research on fashion in the semiotic field is Roland Barthes that through his pioneer essay *The system of fashion* (1967) put the first step to an analysis of semiotics of fashion, which is determined by the relationship between the cultural and social uses of dress and its elements, such as matter, shape and color. Defined by Roland Barthes as an object of communication that possesses an everyday immediate existence and, on the other hand, an intellectual existence (Raymond and Barthes, 1980), fashion in addition to being real artifacts with a functional, protective purpose, is described by the French essayist as a proper language and system of signs imbued with meaning and a deeply symbolic character. Through a semiological approach that relates to the field of linguistics, Barthes describes fashion as a system of values and physical elements, a "true code" (Delyfer, 2019), characterized by the notion of the sign as a correlation between two terms, a signifier and a signified. According to Barthes, a signified is the idea or the concept that is attached to a particular thing, which is the signifier (the garment) which is discrete, material, numerable, and visible (Mikerina, 2016), and that has no intrinsic or essential meaning without the signifier. The signified is considered by Barthes an immaterial and external concept or idea (period, social class, country) which then is embodied in the dress, the signifier (Barthes, 1967). The **sign** is the combination of the signifier and the signified, and the **sign system** is the larger historical system that secures the meaning of the sign within a chain of signs, or in relation to other signs. Actually, in Barthes' conception of the system, singular elements have no meaning *per se*, but just if correlated to the collective dimension of the system.

This analysis of sign systems other than language described by Barthes is the first comprehensive study to show how structural linguistics and phonological analysis could be used as the basis of a sociological approach to clothing and its features.

Citing Ferdinand de Saussure's semiology (Barthes, 1967), Barthes proposes an analogy between language and clothing, proceedings also in a distinction of terms such as "dress" and "dressing". More precisely, for Saussure, langue is the organized system of signs, elements characterized by relations of equivalence and opposition, a sort of social convention that is opposed to words as an individual and unrepeatable linguistic act. In correspondence to Saussure's *langue*, Barthes proposes to distinguish the idea of "dress" from a second, individual reality, the very act of "getting dressed", in which the individual actualizes on their body the general inscription of dress, and which, corresponding to Saussure's *parole*, we will call "dressing". Dress and dressing form, then, a generic whole, for which we propose to retain the word "clothing" (this is *langage* for Saussure). Thanks to this reflection - which may also be considered today out of date (Mikerina, 2016) - Barthes associates fashion and dressing with an abstract lexical state of signs, asserting that a linguistic sign, again according to Saussure, is the resulting product when a concept and sound-image unite (Saussure, 1959).

Fashion as a social system

According to the dress historian Philippe Perrot, clothing represents a wide range of representations and meanings, like language. In particular, it contains "signs, attenuated markings or residual traces of struggles, cross-cultural contacts, borrowings, exchanges between economic regions or cultural areas as well as among groups within a single society" (Perrot, 1994).

Consequently, as Galimberti states, this conception of fashion becomes a rigorous and well-structured system of values that describes and identifies the social and cultural position of the body (Galimberti, 2009). A more concise definition has been given by German sociologist and philosopher Georg Simmel in his fundamental essay *Philosophie der Mode* (1905).

"Fashion represents nothing more than one of the many forms of life by the aid of which we seek to combine in uniform spheres of activity the tendency towards social equalization with the desire for individual differentiation and change." (Simmel, 1905).

According to Simmel, fashion represents both an abstract concept that generates and influences cultural perception and a defining factor in social and interpersonal relations that derives from a basic tension specific to the social condition of the human being that has ever had a dualistic nature (Simmel, 1957). On one hand, each of us has the tendency to imitate others. On the other hand, we also have a tendency to distinguish ourselves from others, standing out from the rest. All people seek an identity and a sense of belongingness through conforming to a given set of norms, and yet at the same time they strive to achieve some distinction as individual human beings (Horn and Gurel, 1981). This phenomenon creates a sort of dualism that relates to the inner and outer struggles that people have. The first is "adaptation to the social group" and the second is its opposite, "individual elevation from it" (Carter, 2003). And Simmel sees clothing capable of inclining in both these directions (Carter, 2003). As Simmel explains, fashion is the effect of an always unstable balance between two opposite poles, that are integration and difference, social equality and individual separateness (Simmel, 1895). Each side of fashion represents a particular standardization of the opposite tendencies in our natures, which are satisfied, on the one hand, by the social form of fashion, and, on the other hand, by its content (Simmel, 1895).

The unstable tension of fashion as a process makes its transitory nature the ideal medium for the study of the definition of norms, that are intrinsically present in all kinds of society. For this reason, Simmel strongly underlines the sociological identity of fashion, stating that fashion is not to be just equated with changes in dress styles over time, fashion is a set of relations, not a set of contents (Carter, 2003). The theory of Simmel is also summarized by Patrizia Cafelato that defines fashion "as a system of social cohesion that allows the dialectical reconciliation of the individual's enclosure within a group and his relative independence in the territory of the spirit" (Fashion Theory, 2022). Due to this strong relationship with society and the individuals, we can consider clothing as a tool that unifies and conciliates two opposite sides of the human being: the human relation with the other and the group and the definition of the self, which derives from the confrontation with the external factors and personalities within a normative system which represents a vehicle of signification.

Color as a signifier

Starting from the conception of clothing as a complex tool for the expression of the self within a structured social system, color, with the shape and the matter, definitely plays a key role in the communication of the message the garment wants to convey.

Although the color is perceived through the sense of sight to give the viewer information about the nature of objects (Da Pos and Green-Armytage, 2006), it combines with social system custom and ideology to bear meanings (Kwon, 2002). Color is an expressive component of the object and its communicative possibility (Vandi, 2019), since, as Tadini says, "Colors, of course, are also words" (Tadini, 1993). In Barthes' example "Blue is in fashion this year", color is presented as a type of signifier (Mikerina, 2016), one of the main vestimentary values (Barthes, 1967), one of the single units for those aspects whose opposition helps create meanings (Barthes, 1967), that can vary from culture to culture with a uniquely defined symbolism (Faerm, 2017) and defined cultural meanings. Color bears meaning in many ways including natural meanings, commercial significance, informational signals, or emotional connections (Bradfield, 2014). More specifically, color has always been considered a specific code of social, economic, and emotional values that evolved during the centuries and that changed along with different societies. As Falcinelli states in his book *Cromorama*: "The whole history of colors can only be a social history. It is the society that makes color, that gives it definition and meaning, that constitutes its codes and values, that establishes its uses and the scope of its applications" (Falcinelli, 2017). About this matter, we can also refer to the studies of Michel Pastoureau and his definition of the role of color in visual cultures and, most in general, in our society: "Any history of color is above all, a social history. Indeed, for the historian – as for the sociologist and the anthropologist – color is a social phenomenon" (Pastoureau, 2001).

The color developed deep symbolic meaning indicating individuals' cultural learning, place in the social hierarchy and economic status (Brannon, 2010). Clothing color conveys attitudes, personalities, and tendencies towards conformity and individuality (Wolfe, 2012) and it becomes a culture through repetitive and customary uses in a certain region and then in a system of signs (Kwon, 2002). Color as such is the only design element that can be studied from a (natural) science point of view and the social science (e.g.: psychology, anthropology, cultural and art/aesthetics) perspectives and each of these perspectives contributes to a wider understanding of this particular phenomenon (Botha, 2006). Perceived as a quality that exists both as an object attribute and as a mental entity (Roberts, Owen, and Havlicek, 2010), Color can also affect attractiveness judgments (Roberts, Owen, and Havlicek, 2010), in particular in the context of an institutional image (Caivano and López, 2006) for fashion brands. As Caivano and Lopez state, color works as a fundamental factor of identification for a company, and in turn, as a factor of differentiation from its competitors(Caivano and López, 2006). Its visual impact, pregnancy, memorability and its faster perception make it an even more transparent factor for defining design and fashion identity than written words and symbols (Caivano and López, 2006).

Gianfranco Ferré design methodology

"And it was here, in New York, on the facade of the Chinese Consulate, that I discovered color. Against the background of a perfect bright blue sky, a red flag stood out, dense with color. This red flag waved as in a dream. More precisely, as in a fantasy Orient, I could imagine a Chinese dragon". (Ferré, 1995, p.11)

Raised and educated as an architect, since the 80s Gianfranco Ferré turn out as one of the most relevant fashion designers of the Italian panorama. Anticipated by his university dissertation, *Methodology of the approach to Composition*, Ferré establishes an approach to fashion conceived as an extremely precise model composed of elementary forms and enriched by his personal and refined sensibility, aiming at a simplicity that would leave women and men free to interpret the style and add decoration on the nature of the moment (Ferré and Frisa, 2009). His rational approach to the construction of a garment is based on a three-dimensional perspective through three main complementary values: matter, form, and color For him, the color becomes an important factor to express his sources of inspiration and exploit the potential of design applied to fashion production. In this context, color has multiple meanings in shaping and communicating Ferré's design which embodies both a narrative and a projecting role in making Ferré's creations so unique and still today a precious material of study.

Gianfranco Ferré's Chromatic Code: signified and signifier

Color is a fundamental tool for Ferré to connect not only different cultures but every kind of expression of life and humanity. Through color, Ferré builds his social system made indeed of signified and signifiers that evokes notions and images but also emotions and, in particular feelings. Through the code and the categories of colors and shades (such as "the glow of metals, flashes of energetic hues, and the delicacy of the tints of dawn and flowers" (Ferré and Frisa, 2009)) Ferré explains and illustrates the meaning behind the garments and, most importantly, the reason that leads him to the realization of the collection. Every color (signifier) refers to a deeper meaning (signified) that can be a city, a culture, or a historical moment. His tones and nuances form, in turn, a more multifaceted language, variously expressing energy, poetry, magic, seduction, purity, opulence (Ferré, no date). The Japan of the courtly dress, the China of simple and elementary forms; Eastern teachings and zen, decoration from baroque to romanticism (Ferré and Frisa, 2009). These are traces that Ferré calls "signs", parts of an ample vocabulary based on culture and human society, referring specifically to Roland Barthes's book *Empire of Signs* (1970).

"It is only without any pretense of analyzing reality that one can take from that part of the world down there a certain number of passages and with these deliberately create a system" (Barthes, 1970, p. 3).

This precious remark that Ferré cites in the press release of the presentation of the collection Pret-à-porter Spring-Summer 1986 connects the designer to the semiology of the French essayist, opening his fashion production to a wider cultural world, the so-called social system that fashion needs to express itself. For Ferré, the study and the cultural exchanges through different cultures, the revisiting of periods and places, the mixing of past and future, of East and West, is a key component of a real social net, a cultural hummus that Ferré defines as the "global intelligence" of fashion (Ferré and Frisa, 2009). The need for contamination that ignores any spatial boundaries is definitely part of fashion's genetic makeup for centuries, as Ferré explains. All inspirations that are to be found in Ferré's collections can be related to an all-embracing project that includes different cultures and traditions and that is expressed through the use of colors.

The use of color is so important in Ferré's creations that his homage to foreign cultures is always expressed by a choice of colors based on his favorite ones: white, black, red, blue, gold (Ferré, no date). Then, new tones enrich Ferré's palette, coming from a series of extraordinary travel experiences.

He describes in detail the chromatic impressions of Eastern, South American and other foreign cultures in their everyday life, enlightening the differences and the common points with his culture and provenance: the ocher walls of Bombay's buildings, the light gray linen sari of a woman at the Taj Mahal (Maddaluno, 2014), the contrasts of blue and yellow, of green and red of the buildings of St. Petersburg, the sumptuous coral red of Chinese imperial silk (Ferré, 1995).

These experiences and the contact with other fascinating cultures not only strongly influenced the production of Gianfranco Ferré, but they definitely became part of his style and his lexicon – "I wonder which features I have taken over while proceeding on a journey toward eastern cultures" (Ferré, 1986, p.1) - shaping a new sensibility that is then translated in a color lexicon where every meaning is embodied in a color. Therefore, it is evident the relevance of the chromatic code of every collection, as the result of a deeper study and elaboration that includes the history of cultures and his inspiration – "the lands of the rising sun and China seen from a European observatory"

(Ferré, 1990). Every color has a specific meaning - "energy therefore red, purity therefore white, balance, therefore red and blue…" (Ferré, 1986) -, and it is related to an image or real-life experiences. As a consequence, color is a code that helps Ferré to deconstruct the features of the foreign cultures to reset them through his personal taste and sensibility: "I mixed feelings, images, and cultures to get to this oriental softness" (Ferré, 1990). Paying homage to these cultures for Ferré is a symbol of friendship and appreciation which brings enrichment and uniqueness. The mix of colors and materials allows to go his any difference and discrimination to represent through the pieces of the collection an ideal dialogue between cultures and people "in devotion to quality and beauty, in love of harmony and equilibrium" (Ferré, no date). In this case, the color is a true expression of joy that impress the man and became a form of culture (Maddaluno, 2014), applied to fashion.

The projecting role of color

The approach of Gianfranco Ferré to the use of color in his creative and project process aligns with the common spirit of fashion in the 80s. According to Gillo Dorfles, the main values of fashion at that time were structure and color (Dorfles, 1999). If the structure allows establishing a clear and recognizable design to the dress, color enriches the form, it gives flavor and taste.

In what we call Ferré's creative process, Ferré himself underlines the strong importance colors have for him and his working method: "My imagination always operates in technicolor" (Ferré, no date). The choice of colors is completed by shape and matter, realizing unique and irreproducible combinations of form and substance for expressing and conveying emotions, enhancing the body of the wearer. For this reason, the selection of the shades of color is always considered by Ferré an "intentional" act that demonstrates that the color is already a part of the idea of the dress at the moment in which it starts to take shape (Ferré and Frisa, 2009).

Moreover, for Ferré, color is a tool to enhance and highlight the projecting process of forms and volumes, helping the designer to imagine the final result: "I envision the dress as a splotch of color, a flash of light" (Ferré, no date). In a second moment, the first impression that prefigured the dress is translated into a technical drawing, according to the principles of geometry (Ferré and Frisa, 2009). The immediate shapes designed by Ferré on the white page integrate directly with a lively and lighting palette that also follows categories such as order and geometry, to create coexistences between heterogeneous elements (Maddaluno, 2014).

The realization of the garment as the final result of Ferré's methodology confirms that color has the power to complete shapes and forms, and enhance them, according to the aim of the designer. For Ferré it is possible to discern "absolute colors" and "non-colors" (Ferré and Frisa, 2009, p. 53). They are two complementary aspects of the creative process of Gianfranco Ferré that used them depending on the stories and atmospheres he wanted to tell. Strong colors are for Ferré red, blue, gold but also green, bronze and yellow. Rich in history and significance, these colors are fundamental to understand the references and the sources of a piece, since they convey meanings through a sophisticated level of interpretation. For example, what Ferré defines as "energetic colors" or the "colors of the signage" (Ferré, no date) are strong and lively tones and shades that underline the beauty of the materials. This is mainly the case of red, "the color of life" (Ferré, no date), but also of Imperial China, Titian's paintings and African tribalism. Thanks to its sensual spirit, red conveys passion and a feeling of fullness, "like a tattoo, magical symbol on a woman's skin" (Lucio del Pezzo, 1993). Also gold and metal colors have an important physical and semiological relevance for Ferré. As he says, "gold is the reflection of a metal […] with thousand souls and meanings, an emblem of power and wealth, that lights up garments" (Ferré, no date).

On the other hand, Ferré appreciated also neutral colors, which are always synonymous with simplicity and cleanness, values that are dear to the Lombard designer: "Basic colors thus join more

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delicate and more nuanced natural tones in an infinite series of shades and shadings, enhanced and completed by some concessions to the imagination and the themes of the collection" (Ferré, 1995, p. 13). In particular, in the case of the distinctive series of white shirts, white color gives the garment a universal identity and a special appeal, an expression of natural elegant femineity. White is a transforming design tool that can highlight an ensemble or be a discreet complement to it. Its uniqueness and the metaphorical negation of the tints allow to underline the forms and exalt the matter. Among other neutral colors, for Ferré, colonial beige leads to a colorless abstraction, grey makes the dress "evanescent", while black is the most versatile of non-colors, rigorous and sensual at the same time, able to enhance everyone, since it is seasonless (Ferré, no date).
The systematical combinations of connotations and meanings, through color, material, and shape, emerge in Ferré's fashion production as an infinity of variants that comes from a technical and rational process that collects all the signs of Gianfranco Ferré through rather an impactful pictorial expression.

Conclusion

The particular methodology of Ferré is defined as a real "lexicon" – as he said – a kind of alphabet concretely applied to the material and the design form in a wider global project of style moved by rational interpretation of the process and an emotional journey through growth and maturing. According to his extremely rational creative process, Ferré affirms that color must take its place in fashion creation, and most of all it has to justify its presence and existence on that specific garment.
Intentional and necessary, Ferré's colors display a character that remains coherent and faithful over time, even though capable of infinite modulations, season after season. Related to emotions and feelings, color is the perfect joint point that unifies the romantic and extremely rational view of Ferré about fashion, to give concrete expression to his imagination. As a tool to remind of feelings, experiences, the color gives Ferré's creations a real substance and a narrative that enhances the structure of the garments and gives sense to all.

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9. Color and Culture

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Colour Harmony in Design and Architecture: theory, practice, education.

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Abstract

The harmony of colour is a universal, transcultural phenomenon. Whether the creation of images, the invention of drawings for the design industry or the construction of urban spaces, it represents a system of coded messages of the visual world that helps us to apprehend, evaluate and act in different contexts. Through the prism of historical and intercultural approach, our study shows the evolution of colour harmony and invites you to an imaginary journey into the infinite universe of colour harmony in different cities of the world. Throughout space and time, it shows us how the phenomenon of colour and its symbolic language have evolved alongside the civilizations.

Keywords: colour harmony, evolution, art, fashion, design, architecture, environment, education, artistic movements, architectural styles, cultural identity.

Introduction

Beginning from the time of primitive civilizations, they are not selfgenerating but are in constant dialogue with environment. They could be abstract or figurative, monochromatic or polychromatic, composed of earth materials or designed with modern tools and technologies. Nowadays, the layered image of the modern town society consists of multiple *chromoplastic* levels that give dimension and refer to organizing the distribution of values. The choice of colour harmonies tells us about historical-ethnographic, ethnic origin and the palette of local material shows us the relationships between different cultural and geographical contexts. (Fig. 1).

Fig. 1 - The choice of colour harmonies in different cultural and geographical contexts.

Our study is at the crossroads of artistic, architectural, and urban environmental design studies, based on historical and scientific reasoning. We propose the system of 24 colour harmonies classification which help us to explore the infinite universe of colour relationships in Art, Fashion design and Architecture. The results of these investigations are the part of educational programs for students that we developed for different grades of academic studies according our own practice of many years teaching in Art & Design School and Universities (Fig. 2).:

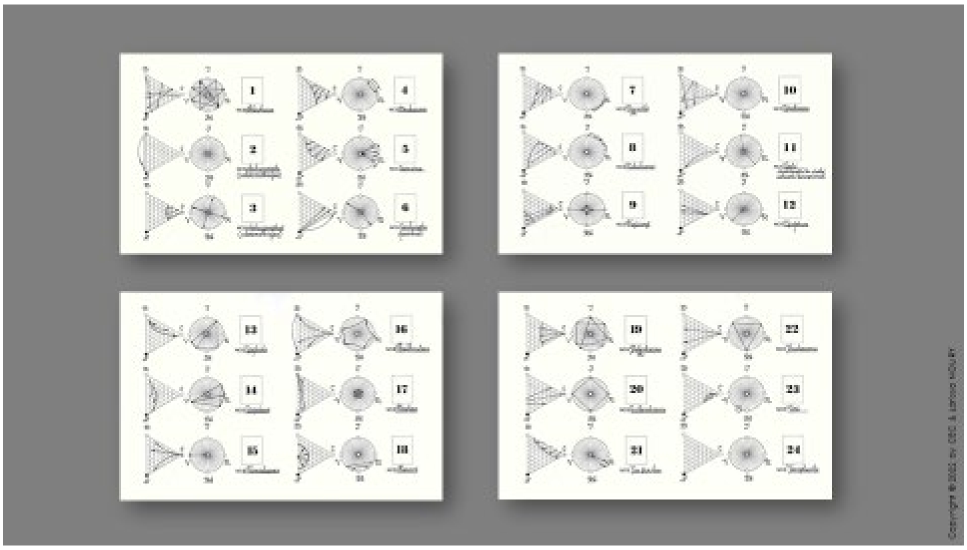

Fig. 2 - The system of 24 colour harmonies classification.

- The goal is to help students think creatively and express their own personal perception, taking into consideration the diversity of world cultures, the different styles, art schools & movements of the XXth century. Art as a crossroad between visual and applied fields of art. Classification of Colour harmonies associations.

- Art & Visual harmony with environmental design and architecture. Fine art, visual communication, symbolic and cultural traditions in art and design: web design, motion design, and visual communication, digital and Immersive art, video installation.
- Image of the city and cultural identity, design & architecture of modern cities from antic civilization until XXI century.

- Artistic movements & architectural styles trough the history of society and different cultures.

- Sustainable solutions in design and architecture. Ecology, design and public space. Visual identity and urban environment, colour harmony on city's design.

Conclusions

A profound analysis of colour harmonies in design , build environment and existing situation is a primer importance of our investigation.

The process of visual analysis & colours of architectural design goes with the help of "Harmony of Colours" software. (Fig. 3).

Educational programms in High Fine Art and Design School should includ the applied study of Classification of Colour harmonies associations in order to help students think creatively and express their own personal perception, taking into consideration the diversity of world cultures, the different styles, art schools & movements of the XXth century.

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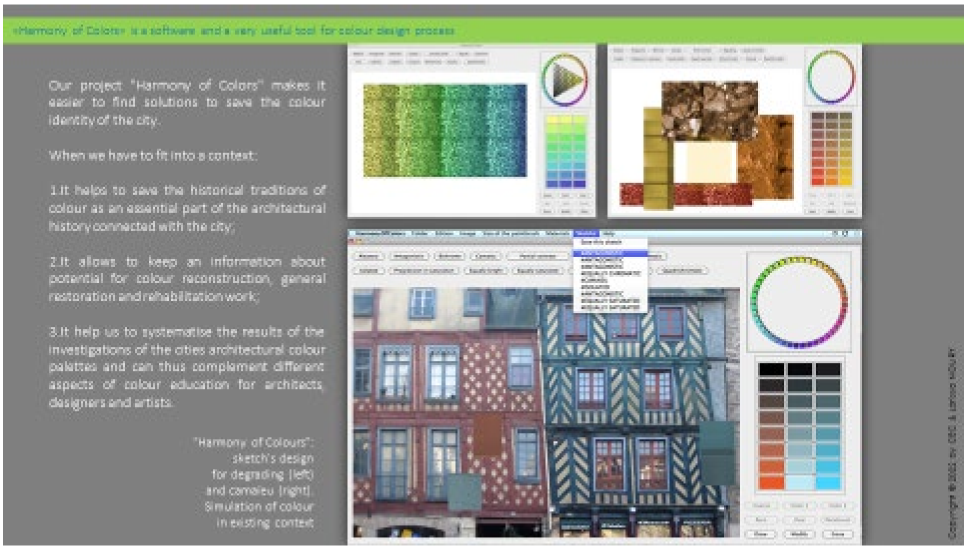

Fig.3 - The process of landscape visual analysis & colours of regional architecture goes with the help of "Harmony of Colours" software.

Fig4- The exemple of student work on Polychromatic harmony.

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The "Pink Mask Affair": Why did Italian police refuse to wear pink FFP2 masks?

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Abstract
On 13th January 2022, some Italian police stations received stocks of pink FFP2 masks to protect them from covid-19. Many officers however refused to wear them because the colour would not be appropriate for a police officer, alerting the Sindacato Autonomo di Polizia – SAP. This article aims to revisit this "Pink Mask Affair", to identify and detail the reasons which could or might have led police officers to refuse to wear pink masks. It proposes two hypotheses: 1) the association of pink with feminine and femininity could have led male officers to refuse to wear pink masks for fear of being perceived feminine; 2) bright and pastel colours are not suitable for police officers because they are also associated with femininity.

Keywords: Pink, Masculinity, History of colour, Italian police, Covid-19 pandemic.

Introduction: A look back at the "Pink Mask Affair"

In late December 2021, the Italian government reinstated the wearing of masks outdoors in the context of an upsurge in coronavirus infections due to the omicron variant (Ministero della Salute, 2022). On January 13th 2022, several Italian police stations in Pavia, Varese, Ferrara, Syracuse, Bologna and Venice received batches of FFP2 masks from the office of the covid-19 Emergency Commissioner, Francesco Paolo Figliuolo. On opening the boxes, the police officers were surprised to discover pink masks, which many officers refused to wear because the colour would not be appropriate for a police officer. Alerted by the facts, Stefano Paoloni, secretary general of the Sindacato Autonomo di Polizia – SAP, one of the country's police unions, even wrote a letter to the police prefect Lamberto Giannini, asking him to immediately replace these "absolutely inappropriate" masks with other ones coloured in blue, white or black, "in accordance with the uniform of the State Police" (Paoloni, 2022a). According to him, wearing pink masks would indeed harm the image of the police: "the importance of the functions performed by the State Police requires the administration to preserve the propriety of its officers and to avoid that they are ordered to carry out institutional activities wearing protective equipment of a colour eccentric to the uniform and likely to damage the image of the institution" (*ibidem*). To support his point, Paoloni also cites a circular from the then Chief of Police, dated 29 October 2019, which had warned members of the police against wearing non-conforming clothing that could damage the institution's image (*ibidem*). Immediately picked up by the local (*e.g.* Gasparini, 2022) and national (*e.g.* Ziniti, 2022; Frignani, 2022) press, what I will call "Pink Mask Affair" (hereinafter "PMA") soon spread beyond Italy's borders to Europe (*e.g.* Giuffrida, 2022; Lutaud, 2022) and the United States (*e.g.* Povoledo, 2022), a fact that the union proudly boasts about on its website (SAP, 2022a; SAP, 2022b).

Based on the statements of the SAP and its members, the press coverage of the event, and the reactions of Internet users on social networks, using visual semiotics and relying on gender studies, this article aims to revisit the PMA. The point is to identify and detail the reasons that could or might have led male police officers to refuse to wear pink masks, and the SAP to take up the subject to the point of making it a national controversy, even though Italy was still recording tens of thousands of daily covid-19 infections in January 2022. To do so, I will first look at the association of pink with feminine – understood as a social and conceptual category or as an essence – and femininity – a set of external attributes (appearances, behaviours, etc.) culturally associated with the feminine –, which could have led male officers to refuse to wear this protective element, for fear of being perceived as (more) feminine, or even homosexual. As Paoloni assures us that the SAP would have had the same reaction if purple or green masks had been used

(2022c), I will secondly look at the reasons for the refusal of some police officers to wear such colours, by going back to the historical rejection of bright and pastel colours in Europe.

Masculine police/feminine pink: a symbolic incompatibility?

In protesting against the wearing of pink masks by police officers, the SAP was quickly mocked and accused of sexism – particularly on social networks –, associating the rejection of pink with a rejection of feminine and femininity. Indeed, for more than a century, pink has been a symbol of femininity recognised almost everywhere in the world and, by the principle of gender exclusion – *i.e.* what is feminine is not masculine –, any association of pink with masculine or masculinity generates a symbolic incompatibility (Bideaux, 2021, p. 661-665). The pink/masculine incompatibility arises from the discrepancy between what the semioticians of the Group μ have called the degree of perception (observable) and the degree of conception (unobservable) which are superimposed in the reception of an image (1992, p. 256). It is therefore not a matter of the perceived or the conceived, but of the to-and-fro between these two degrees and only the spectator can stabilise the back and forth between the two readings (Fontanille, 1996).
Thus, while for centuries men have worn pink without their masculinity being questioned (Bideaux, 2021, p. 646-649; Steele, 2018, p. 9), the contemporary association of pink with masculinity is not without effect on the perception of masculinity, leading to rejection and violence in some cases. The reason so few men like or wear pink today is that they see pink as having feminising effects that they fear, because to fit the stereotype of hegemonic masculinity – as described by Raewyn Connell, *i.e.* as an archetypal ideal of powerful and dominant masculinity (1995) –, one has to be virile and devoid of any feminine qualities (Sherman, Allen and Sacchi, 2012). This is why, in 2005, the visitors' locker rooms at the Kinnick Stadium were painted pink, and why certain prisons have some of their cells painted pink: to signify respectively to the guest team's players and to the prisoners that they are feminine and therefore weak, in areas (sport, prison) where masculinity is over-valued (Buzuvis, 2007; Bideaux, 2019). There is also a link between pink and male homosexuality, according to the common stereotypical association between femininity, effeminacy and male homosexuality (Éribon, 1999, p. 98; Tamagne, 2002). Therefore, men with feminine features or wearing feminine attributes can also be perceived as homosexuals regardless of their actual sexuality (Fraïssé, 2003) and be victims of homophobia (*e.g.* Harding, 2014; Beresford, 2016). Homophobia then becomes an essential mechanism of gender because it allows the reassertion of heterosexuality by guaranteeing the exercise of masculine power over the feminine, including within the category of "man" (Borillo, 2001, p. 85-92).

Pink then stands at the crossroads between misogyny and homophobia because it is used to insinuate the undesirable trait of femininity (Bartow, 2008, p. 43). The association of pink with femininity and male homosexuality is one of the main reasons why pink is so rare in men's wardrobes: many of them are reluctant to wear it for fear of being perceived as feminine or even homosexual. The refusal to wear these pink masks by male police officers then could be interpreted as a macho reaction to the fear of being perceived as more feminine or homosexual, which would undermine their status of authority and their position of strength. In the SAP newsletter, Paoloni writes that "wearing pink masks could have caused hilarity among the staff on duty", suggesting the undesirable aspect of this incompatibility between the colour pink and the police function (2022b). Another police union, the Sindacato Italiano Appartenenti Polizia – SIAP, was quick to react to SAP's positions with a press release, denouncing the SAP's "'machismo' and medieval nonsense based on chromatic assessments" (Nicolosi, 2022). Still reacting to the SAP statements, the SIAP's Palermo branch added a pink mask to its logo on *Twitter* (**Fig. 1**) and initiated the hashtag *#mascherinerosa* [#pinkmask] (2022). This last one was quickly taken up by internet users to spread memes or photomontages on social networks, some considering the refusal to wear the pink masks as a flaw in the masculinity of the police officers (**Fig. 2**), others making a mockery of what they consider to be a futile concern in times of pandemic (**Fig. 3**). Some others supported the position of the SAP, creating and disseminating images that are humorous and based on sexist and homophobic rhetoric that negatively associates the wearing of pink with the feminisation of male officers (**Fig. 4**), or even a homosexualisation of them (**Fig. 5**; **Fig. 6**).

From right to left: **Fig. 1** - SIAP's logo modified by adding a pink mask (SIAP Palermo, 2022); **Fig. 2** - Meme criticising PMA, refering the masculinity of some policemen as "fragile" (FriendZone, 2022); **Fig. 3** - Meme parodying PMA based on a Disney movie scene (Luigi, 2022).

From right to left: **Fig. 4** - Meme associating PMA with feminisation of policemen (Automatizzato Comunismo Memetico, 2022a); **Fig. 5** - Other meme mocking PMA as a feminisation of policemen, also insinuating their homosexualisation by adding a butt plug as police equipment (Automatizzato Comunismo Memetico, 2022b); **Fig. 6** - Meme parodying PMA as transvestism and homosexualisation of policemen (JoKakamuKazz, 2022).

Police culture and practices have indeed been constructed since the 18th century in connection with ideologies around masculinity (Barrie and Broomhall, 2012), and even more so in Italy. Indeed, the construction of masculinities in Italy has been highly influenced by Catholicism (Crespi and Ruspini, 2014), fascism (Bellassai, 2005) and Mediterranean traditions of honor and shame (Blok, 1981); they have thus been constructed in strong opposition to femininities, contributing to the maintenance of a macho, misogynistic and homophobic culture (Tager and Good, 2005; Callahan and Loscocco, 2021). However, as Polis Aperta, the LGBT association of the armed forces and police, reminds us, "some police officers are not the police officers, one union is not the unions", and also recalls that, since 1981, women have also had access to the functions of police officers, and that, furthermore, not all police officers are heterosexual, nor are they all cisgender (2022). Thus, to summarise this event in a totalizing male narrative would be to place the plurality of individuals within the police on a few police officers and a single union, as well as to make invisible the actions carried out by certain police officers within this institution in order to deconstruct its macho practices and culture. In addition, it should not be forgotten that hegemonic masculinity, and the patriarchal and heterosexual binary vision of society are not particular to the police, but to society as a whole, as proven by the above-mentioned images posted by internet users. By understanding the rejection of the pink mask by some police officers as a rejection of the feminine and femininity that pink symbolises, we are also validating this association that has been built up over more than a century from prejudices and sexist stereotypes about women and homosexual men.

Police power/colourful frivolity: a second symbolic incompatibility?

Unsurprisingly, the SAP rejected all accusations of machismo, insisting on the need to preserve the sobriety of the police uniform, which should reflect an image of authority and respect (Paoloni, 2022b). The PMA would not be a question of rejecting pink, but rather of bright or pastel colours that do not match the navy blue police uniform. Paoloni – deliberately wearing a pink tie (**Fig. 7**) – even spoke personally on this subject on the popular television programe *Mattino 5*, assuring that "there is no prejudice against pink", and that the SAP would also have taken a position against the wearing of red socks (Paoloni, 2022c). Moreover, after the police stations in Messina and Ragusa received other packages of canary yellow masks a few days later, on 19 January, the SAP reacted again, with a second letter to the Prefect of Police, demanding the delivery of masks in appropriate colours (Paoloni, 2022d). Beyond a fashion problem of colour harmony, it is more a question of maintaining the image of an institution: "The fact that the women and men of the police must maintain an important sobriety is also indispensable for the image of authority that they must convey. [...] being checked by staff dressed in a disorderly manner, with crumpled clothes and garish, mismatched colours, hardly inspires confidence" (Paoloni, 2022b). Deputy Minister of Infrastructure Teresa Bellanova nevertheless made a point of countering in a tweet, recalling that "there is nothing unbecoming about wearing a coloured mask. [...] Respect for uniforms does not come from the colours, but from the way the men and women who wear those uniforms act and work" (2022). Internet users in the same vein were also keen to point out on *Twitter* that the alleged "indecency" of the pink masks was nothing compared to the indecency of police violence, posting photos of people beaten or even killed by the Italian police (**Fig. 8**).

Left: **Fig. 7** - Paoloni wearing a pink tie, interviewed about PMA (2022); right: **Fig. 8** - Meme relativising PMA by denouncing Italian police violence ('O Strunz, 2022).

Such a position stems from a long history of rejection of colour in clothing, and which also lies in the valorisation of the masculine over the feminine. In the 14^{th} century, the Protestant Reformation contributed to the decline of colours, which it considered a symbol of luxury and sin. The reformers particularly disliked red, which they considered an abomination, associated with Papist Rome, "scandalously adorned in red like the great Prostitute of Babylon", whose commercial excesses they rejected (Pastoureau, 2008, p. 159). Colours then disappeared from the Protestant aesthetic, first in temples and cults, then in painting and in clothing. Throughout Europe, colours that were too conspicuous (red, yellow, pink, purple, etc.) were banned, deemed dishonest, impure or even obscene, in favour of darker colours (black, grey, brown or blue if kept discreet) which were associated with simplicity and severity (Pastoureau, 1992). The chromoclasm of the Reformation popularised black in Europe from the middle of the 14th century, especially in Italy, among the merchant bourgeoisie who were wealthy but had not yet reached the top of the social ladder (Pastoureau, 2008, p. 100).

After a colourful 18th century characterised by rococo painting (Minguet, 1966), dark colours made a comeback in West-European men's fashion around 1760. John Carl Flügel pointed to a male rejection of the flamboyant clothes of the aristocracy, which he called the “great masculine renunciation”: “there occurred one of the most remarkable events in the whole history of dress […]: men gave up their right to all the brighter, gayer, more elaborate, and more varied forms of ornamentation, leaving these entirely to the use of women, and thereby making their own tailoring the most austere and ascetic of the arts” (1930, p. 110-111). Men therefore abandoned ribbons and other accessories, but they also abandoned bright colours: black, grey and navy blue had become the dominant colours in Europe for men's clothing, leaving bright and pastel shades to women (Steele, 2018, p. 25-26). During the 19th and subsequent 20th centuries, dark colours – and black in particular – continued to be associated with masculinity, becoming the dominant colours of bourgeois men's clothing, referring authority, elegance, and modernity (Paty, 2021). These same colours are nowadays still associated with seriousness, success and power: they are the colours of the suits of bankers, politicians and, what is particularly interesting here, of police.

Dark colours have thus been opposed to bright colours for about eight centuries, and one can guess that behind the “moral” classification of colours there was already the bicategorisation of gender, since the characteristics associated with each are those associated respectively, and in a hierarchical manner, with men and women. On the one hand, we have virtuous, modest, sober, practical, serious colours, associated with the masculine; on the other, we have debauched, sumptuous, flamboyant, superficial, frivolous colours, associated with the feminine. We can still see that dark colours today share the same status of universal referent with the masculine: indeed, it is enough to look at people passing by in the street, travelers on public transport or any person in supermarkets to realise that black, blue, grey and brown make up the majority of the contemporary clothing palette, for both men and women. Wearing pink, red, yellow or green is always a noticeable deviation, especially when it is a man wearing these colours – except for certain men belonging to the social, cultural and/or intellectual elites for whom wearing these colours will be a way of showing that they are able to distance themselves from social conventions (Bideaux, 2021, p. 693-696)

By calling for the replacement of pink (or yellow) masks, stating that “being inspected by staff dressed […] in garish and mismatched colours would hardly inspire confidence in anyone” (Paolioni, 2022b), the SAP thus validate – even unintentionally – this gender-related moral order, constituted around the bicategorisation of colours according to their hue. They also place the police as an institution superior to others, since by suggesting a mistake in the distribution of packages, they implicitly mean that only the police should not wear brightly coloured masks, unlike the teaching or medical professions for example. Once again, we must maybe look to men and hegemonic masculinity for a response to this overreaction on the part of a police union that is not found in other professions. As a profession in which they hold power – over women *and* over other men – policemen are more likely than other men to fear losing the power that defines their manhood (Kimmel, 2012). More than other men, they are therefore compelled to ensure that they prove their masculinity, and are thus more likely to refuse to wear a pink accessory that might interfere with the perception of their manliness or heterosexuality (*ibidem*), even if this accessory guarantees them health protection.

Conclusions: Masculinity beyond fashion and good taste

This detailed analysis of the PMA has led us to identify correlations between colours and gender categorisations (pink as a symbol of femininity, the opposition between bright and dark colours). This may partly explain the reasons that led the SAP to take an official stance against the a priori involuntary receipt of pink masks packages in several police stations, assuming that the refusal of some (male) police officers manifests a fear of loss of masculinity, heterosexuality and power. However, this also assumes that one adheres to and therefore validates both gender hierarchies and categories, but also the symbolic system that associates pink with feminine and femininity, or more generally that associates bright and pastel colours also with feminine and femininity. The problem is therefore twofold: on the one hand, the masculine hegemony is supported by considering it different from and superior to the feminine, and on the other hand, a self-fulfilling prophecy is created which leads to the association of pink or bright and pastel colours with the masculine being considered incompatible. A paradox that Teresa de Lauretis also raises when she writes that "paradoxically, the construction of gender is also affected by its deconstruction" (2007, p. 43).

This futile controversy also shows us the ability of pink to capture attention in the media, especially when it comes to a possible incompatibility with masculine and masculinity, whether it is about fashion, smartphones or the outfit of sportsmen or pop stars (*e.g.* Ovenden, 2017; see also Bideaux, 2021, p. 697-699). In addition, pink attracts more attention than other colours (Lindsey, *et al*., 2010), and a study found that pink is one of the colours – alongside red and violet – with the best impact on the diffusion of an image on *Pinterest* (Bakhshi and Gilbert, 2015), and presumably the same applies to *Twitter*, *Facebook* or *Instagram*. This could explain the quick coverage of this event in the national and international press, and even more so on social networks. It can be further speculated that the SAP sought to draw attention to itself with the PMA, and to enhance the image of the police in media, by reaffirming the values of sobriety, respect and neutrality.

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Grey Zones: On Photography & Progress

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Abstract

Grey is enigmatic, an in-between of color and value, denoting the liminal in semantics and aesthetics. Grey zones proliferate in the processes and trajectories of modernity and postmodernity, as when tracing the consequences of technological development. In this presentation, I will think about the color grey in its aesthetic and metaphorical dimensions through its associations with photography and progress, drawing on the work of László Moholy-Nagy, Vilém Flusser, and Paul Virilio, especially. Evolving from long-exposure plate photography to high-speed shutters to present-day real-time sensory information processing, the technologies of photography and photographic practice have developed through the hands of artists, soldiers, and consumers alike. Their production, proliferation, and use are enmeshed with and constantly blurring notions of visibility, identity, and subjecthood. Modern visuality, itself co-constructed by the use and proliferation of modern photographic and optical technologies, is rife with such grey zones, allowing us to think through the complex socio-political and spatial-temporal arrangements of the moment. I ask: what does the color grey do for us, as we think about technology, progress, and the structures of our world?

Keywords: color, photography, theory, modernity, visuality.

Introduction

My presentation focuses on the color grey. The nature of grey is enigmatic – is it a color? A value? Both or something different altogether? Grey is between black and white, positive and negative. Semantically, we say an issue is a grey area or a grey zone when we are not sure which position to take or where to draw the line, when we cannot see the exact causes and consequences of a path we are on or about to take. Grey is, then, liminal – it is between black and white, positive and negative, right and wrong. It is dialectical, and it is full of possibility.

The processes and trajectories of modernity – and postmodernity – are rife with these grey zones. For instance, when we think about the consequences of technological development and globalization, it is difficult to clearly categorize what we have witnessed, are witnessing, and about to witness into the neat categories of beneficial and detrimental, good and bad, as often times, the reality is in-between. Thinking in this context, Paul Virilio holds that we live in a grey ecology, or "an ecology of the acceleration of reality" (2009, p. 61). Virilio here critiques the speed and instantaneity that structures today's world, which, from his perspective, has come about through the development of photographic and optical technologies and their imbrication in the military-industrial complex. Evolving from long-exposure plate photography to high-speed shutters to present-day real-time sensory information processing, the technologies of photography and photographic practice have developed through the hands of artists, soldiers, and consumers alike. Their production, proliferation, and use are enmeshed and constantly creating grey zones of visibility, identity, and subjecthood.

Interestingly, the color or descriptor of "grey" features prominently in writings on photography and progress from the 20th and the 21st centuries, especially. I ask: what does "grey" do for us, as we think about technology, progress, and the structure of our world? In this presentation, I will think about the color grey, its aesthetic and metaphorical dimensions. Modern visuality, itself co-

constructed by the use and proliferation of modern photographic and optical technologies, is marked by grey zones, allowing us to think through the complex socio-political and spatial-temporal arrangements of the moment.

The Promises of Photography

In his 1936 essay "From Pigment to Light," László Moholy-Nagy lauds the productive potential of photography and tells artists not to fear the influence of mechanization, but to instead embrace it as a new medium and an opportunity for new visual and aesthetic experiences (p. 341). Moving away from manual artistic creation, the photographic apparatus – or more abstractly, the "machine" – must be mastered by the artist, reconfiguring the role of the artist in society as part craftsman and part engineer.

Importantly, the camera alters the speed of vision, and to illustrate this, throughout his writings, Moholy-Nagy cites Étienne-Jules Marey's chronophotography from the turn of the century. In capturing momentary movements via the photographic apparatus and combining them into one didactic image, we are quickly able to gain knowledge about a phenomenon that was previously invisible; a phenomenon once grey, a blur, is now broken into its parts, black and white. Moholy-Nagy thus holds that photography enhances human visual perception through the camera, a training of the eye through the viewfinder and the photograph itself.

Moholy-Nagy's understanding of photographic vision is equated to the advancement of perception and technological development. With the camera, we can slow down phenomena while speeding up our intake of visual data, as through Marey's photographs. The new opportunities for visual expression stemming from the photographic apparatus, as identified by Moholy-Nagy, come to restructure the ways in which information travels, and seek to progress and advance aesthetics and expression. However, while a sense of objectivity defines both photographic process and result, it nevertheless is a grey area, complicated by the structure of the apparatus itself, the imbrication of the photographer, subject, and medium. Vilém Flusser focuses on these ideological implications, understanding photographic images as the product of both camera and photographer, a combination of intentions and ideologies, striving for better images, striving for progress (Flusser, 1984, p. 46). While seemingly objective, such images merely capture moments between other moments, rendering invisible the apparatus that makes them.

In *Towards a Philosophy of Photography*, Flusser discusses black-and-white as (optical) ideals, stating that "[t]here cannot be black-and-white states of things in the world because black-and-white cases are borderline, 'ideal cases'", with black as "the total absence of all oscillations contained in light," and white as the presence thereof (1984, pp. 41-42). In actuality, black-and-white mixes to grey, constructed by subtle variations from dark to light; furthermore, "[g]rey is the color of theory," a mix of knowns and unknowns, idealities and realities (Flusser, 1984, p. 42). Flusser laments the black-and-white, yes-or-no positions often taken by modern science. Adjacently, Paul Virilio expresses concern of progress as always being interpreted uncritically as positive advancement; such "progress" must be viewed as a grey zone, underlying the nature of our grey ecology.

A Grey Ecology

Virilio holds that we live in a grey ecology, a world increasingly fast and idealizing progress. He contrasts this to a green ecology, which he understands as the standard look at the state of the world in terms of climate change and widespread environmental pollution. A grey ecology, on the other hand, is not directly physical or material, though it comes about through technologies and their development. Specifically, a grey ecology is the result of the ubiquity of "real-time" telecommunications technologies, originally developed for military surveillance purposes now inundating the everyday. Photography has played a key role in creating this world, as the photographic apparatus is “the first machine of acceleration”; further, “[t]he machine of acceleration is the machine of vision,” marked by “instantaneity” (Virilio, 1989, p. 50). Additionally, “the photograph is the initial case of the acceleration of reality” (Virilio, 2009, p. 59). Speed, both metaphorically and in terms of physics, is key to Virilio’s analysis of the state of the world. As the study of speed, *dromology* is marked by openness, since the relation between phenomena is ever in flux, dependent on the particular (Virilio, 2009, p. 26).

Virilio explicitly connects photography to war and its detrimental effects, writing of the photographic apparatus’ ability to dematerialize the body. He, too, cites Marey’s chronophotography, noting that it made “the body disappear into a momentary agglomeration of sense-data, oscillating between the production of luminous impressions and that pure fascination which dispels perceptual awareness and induces hypnosis or similar pathological conditions” (Virilio, 1989, p. 14). Such a dematerialization, a blurring of figure and ground, is exacerbated in the situation of the soldier at war, particularly as indirect warfare made its debut, wherein “…the soldier had the feeling of being not so much destroyed as de-realized or dematerialized, any sensory point of reference suddenly vanishing in a surfeit of optical targets” (Virilio, 1989, p. 20).

For Virilio, the most important aspect of photography, in terms of its weaponization, is perhaps its effect on distance, an effect it shares with war, as “[t]hrough its hyper-generation of movement, mixing the accomplishments of the means of destruction and the means of communicating destruction, war falsifies appearance by falsifying distance” (Virilio, 1989, p. 32). In war, there is an instability of dimensions in trying to pin down the location of one’s enemy; perhaps the enemy is closer than we anticipate, or otherwise all around us. Photography falsifies distance by rendering the world, the other, readily visible and readily accessible, to the photographer, to the viewer, and, now, given the ubiquity of digital media, to the masses. Photography, with its ability to conquer distances, is a tool of war and of capital, central in forming and experiencing a grey ecology. The photographer, aided by the technical capabilities of the camera, has power and knowledge; nevertheless, when the main strategy of war becomes concealment, it is difficult to point the finger at any one enemy, and a sense of wariness pervades – a grey zone, marked by suspicion.

The pollution of distance comes about through the temporal contraction brought on by advancing telecommunication technologies, a byproduct of globalization in which the world is shrunk through real-time and instantaneity. This amounts to “a new type of accidental catastrophic ecological transfer,” albeit one that “leaves no trace” given the speed at which it occurs and the way this process is viewed as “incontestable progress” – a positive thing (Virilio, 2009, p. 39). Yet this transfer does leave a trace, as socialization is reconfigured (and re-networked through electronic devices and ever-updating social networking sites), the environment is subject to extraction, and energy is consumed to keep us online. We are embedded within a grey ecology, navigating a world of confused distances, in which dimensions and speed are not quite calculable, given the simultaneous relativity and imminence of, frankly, everything.

Conclusions

Drawing from the idea that a grey zone is a liminal space, Jeffrey Jerome Cohen writes that a grey ecology is “inhuman,” with grey, a “polychrome hue of the in-between and the uncertain, a miscellaneous zone” being “a process more than a color” (2013, pg. 271-272). In suggesting the inhuman – and the undead, or differently alive – Cohen suggests that a grey ecology decenters the human, making possible not only object-oriented ontologies but also an analysis of the extractionist and imperialist ideologies that structure the production and labor underwriting technological development. Following Cohen, we can move from Virilio’s and Flusser’s critiques of the military-industrial complex and its weaponization of photographic technologies to questions of biopolitics and ecocriticism.

Cohen continues his description of a grey ecology; it "…teems with varying densities of matter and shifting velocities: stormy thicknesses as well as serenely heterogeneous clumps..., composites and microclimates" (2013, p. 271). We are reminded of the fragmented quality of Marey's photographs, capturing moments of processes. Marked by relationality of conglomerations, a grey ecology is open to interpretation and open to speculation of what is beyond. The color grey is thus a color of possibility, denoting to us the consequences of progress, its accidents, its collateral damages. Grey reminds us to open some distance and make some space, to embrace questions of uncertainty, complexity, and complicity, to better reckon with our own positionalities among the myriad of relations enfolded within its fog.

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Reversal film transparencies and their colours: examining the medium of an era

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Abstract

Colour reversal film transparencies (slides) are a medium that seems to have, almost, disappeared. They gained their prominence mostly between the 1950s to 1970s, as a preferable photographic choice, since their vibrant colours gave them an edge over negative film photographs, not only as a professional option but also as a means of recording family moments. Slide showing became a social activity. The gathering of people, cinema-like conditions and interaction made them quite popular. The question which we will concentrate on is about their colours and how this is consistent with the colour palette of their era. In the current study source material, from a family collection, is utilised and an empirical approach and analysis is applied. The study concludes that the medium employs the colours of their times, and how this helps with the preservation of these items, not only as family archives but as cultural objects enriched with semiotic elements.

Keywords: slides, transparencies, colour, images, semiotics, social interaction

Introduction

Colour reversal film transparencies, short for colour reversal film transparencies slides, were, predominately, a 1960s and 1970s phenomenon. Transparencies were presented, usually, in a session known as slide show. They were a single framed pieces of 35 mm film, framed in a 2x2 cardboard or plastic casing which could be viewed usually on a screen, through the usage of a specialised projector.

In the case of image analysis, when examining transparencies, the pivotal question which arises is whether transparencies can be examined and analysed in the same way as paper printed photographs. They could be labelled as an easy and affordable alternative to home movies, in a society where images are important, and moving ones doubly so. And since amateur photography boomed in the 1950s and 1960s, with the mass production of cheap and easy-to-operate photographic cameras, images started flooding the home moments scene. Their main purpose was displaying family moments and holiday snapshots. This of course does not mean that amateur photographers did not record everything they could: their houses and gardens, their children growing up, country fairs, new additions to their surroundings and much more. Thus, the produced items were a welcome addition to the printed images, which constituted the main bulk of the recorded family moments. But the crucial difference with photographic images was the act of slide showing. Printed photographs were stacked in albums, which could be seen by many, but was a static process or at least a one-on-one happening, usually. And they were smaller than life. Transparency showing, on the other hand, was orchestrated along different lines. The whole event included, almost always, a commentary along with the projection of every image shown. All this took place in a semi-dark room, with a group of people, almost like a private cinema screening and the free flow of everyone participating in this happening, with their own comments about the images, something which made it something more than an informal gathering. It was a social interaction event.

The transparencies examined here are simple images created with one thing in mind: an archive of a Moment in Time. A semantic approach to the transparencies involves understanding what exactly is what we see in them. The interesting fact is that the researcher is in the unique position to understand, to a great degree, the creator of these transparencies. Almost all were shot between

1968 and 1972. The images involve two kinds of participants: represented and interactive. The choice of using this approach can be understood better if we try and understand the relation between the original producer and the original intended viewers. This is especially true in the first transparency (Fig. 1). The image is a view of a small town's main street. Collaborating information can be gathered by studying the surroundings, but as both the date and the place are known it is not necessary to go into those details. The represented participants are not people, it is the place itself.

Figure 5 Lourantos J (photographer) (early 1968) Neal Street, Harden, NSW, Australia [transparency] (from the researcher's collection)

The second transparency examined (Fig. 2) contains also involvement and detachment. It is another typical tourist holiday snapshot. Here there are represented participants, which are people, but the place is also of importance.

Figure 6 Lourantos J (photographer) (mid 1968) Family members riding donkeys, near Chora, Kythera, Greece[transparency] (from the researcher's collection)

The picture was shot during the producer's holiday back to his birthplace island and village. Depicted are family members residing on the island. The angle is frontal, at eye level. Yet he is a tourist. He does not reside in this place. He is visiting. The depicted participants may not be the interactive ones. The persons shown will not see their image, probably, but others will.

At this point we may use Barthes' (1961) view about the duality of the photographic image, something he calls the 'photographic paradox' He suggests the co-existence of two messages within a photograph: the analogue (message without a code) and the connoted message with a code based on the 'art, treatments or rhetoric of the image' As a result, transparencies are exactly what Barthes (1977) describes: '*Certainly the image is not the reality but at least it is its perfect analogon*' In the case of these transparencies, which are naturalistic images, the connoted message is what the interactive participant is trying to invest in it. Thus, transparencies are images, but with a twist.

Research Methodology

In choosing a methodology to the research question, the choice between quantitative and qualitative approaches was considered. A quantitative approach would seem appropriate, as the total of the transparencies collection examined in our case study is not large in number, since it consists of about 60 transparencies. But such a method is suited to mechanistic 'what?' queries. The study's question demanded an approach founded in the special characteristics the source material was invested with, and which is definitely not mechanistic, per se. In contrast a qualitative approach to the query seems a much better suited one, as it helps understanding the ‘why?’ and ‘how?’ questions. We decided that the qualitative approach was preferable. The study’s question focuses on the fact that transparencies are an item which is and is not an image, like an ordinary negative film printed photograph. There is therefore a need to have a small, yet representative sample. This study adopted a convenience combined with a judgment one, as it was decided that certain transparencies would be more productive than others, and specific choices had to be made. The choices could be challenged as biased, but they are not. The viewing of any image associated with one’s early ages, whether their own or not, is emotionally moving and invested with denotation and connotations and emotional impact. Sampling for qualitative research is something of a confusing part for any researcher. The aims of such an approach have to do more with trying to comprehend human issues rather than producing answers, with general attributes. In the case of this study only a minute number of transparencies was selected: no more than seven, in total (one was used both for chromatic as well as semiotic analysis). Results produced may seem a little generalised but an empirical qualitative approach, with convenience and judgement sampling, seems to have produced enough data to analyse them, by utilising a fundamental theoretical semantic background and a chromatic relativity approach.

Colour of the transparencies

The chromatic approach of this study’s transparencies will concentrate on colour relations. Transparencies contain information and can be treated as any other photographic image. Their dualism is a result of the extra quality of their projection.

The field of Plastic Visual Semiotics was an attempt to make sense of the confusion of the visible with the speakable (Floch, 1985). Barthes through his semiotic approach is a way, yet not the only one in a sociological analysis, which may try to connect these different ideas and understand its links with specific eras (Skarpelos, 2018). Greimas (1989) talks about visual plastic semiotics containing a chromatic category, which beyond colour may refer to attributes such as luminosity and texture. Žemaitytė (2017) points that here we may have categories with graded characteristics, related to the perception of colour and matter. There seem to be different three origins, which Darrodi (2012) labels as colour semiotics. The first is the emotional impact of colours, the second is colours having socioeconomic origins and the third that certain colours meanings are cultural in origin. This case study stands on the fact that colours do have an emotional impact, as when transparencies introduced colour on a wide scale it was a novelty. And since the images were not only coloured but larger than life, they did have an impact, when viewed in the correct conditions. From that point the study elaborates that in the 1960s and 1970s colour images had all kinds of impact on people. Technology enabled colour to become a major part of everyday life: textiles, magazines, and photographs. This made transparencies a major force in the image game, as printed film colour photographs still lagged behind. Colour, consequently, was the factor which enabled the ascendancy of the transparency medium. And as it is still present, and has not faded, from our images examined, it allows us to see exactly what the viewers of the 1960s saw: vibrant, colourful moments on a big screen. While examining how professionals’ utilized transparencies the thought of experimenting with colour palettes and comparing transparencies with other, similar, images of the era arose. The fact that every era has a chromatic palette is not new. Best (2017:285-286) notes that through time there’s a need to have “*the right colour and design for the right period*”

Barthes (1977:39) introduced the idea of the “*terror of uncertain signs*”, when he noted that images need linguistic messages, in order to fight of their own polyseme. But transparencies do not have a textual linguistic message. In their initial presentation the linguistic was present through the usage of the interpreter-creator, but this in not textual. So, when trying to analyse such images, after finishing with the morphological analysis we end up having to deal with their extra attributes and we stand still as he has talked meagrely of them. Barthes’ essays on Pop Art and Edwin Parker "Cy" Twombly Jr. are important as examples on the aesthetics of colour. Riley (1995) comments on these saying "*Barthes allows colour to expand into a broad-ranging role in aesthetics. Its deployment can be enough to confer 'artistic' status even on an object that has deliberately categorized as unartistic or antiartistic*" Colour is a part of the visual narrative of the transparencies. We would go as far as supposing that the 1960s pop colour boom created a new idiom, in items such as transparencies, something which has not been approached systematically, from a semantic point of view. This made us consider the possibility of trying and exploring the idea of a chromatic era palette, for the transparencies studied.

Consequently, the need to compare transparencies with other cultural artefacts of the same era arose. The only logical choice to compare them with is film stills, from home movies of the period. Both are part of what Chalfen (1987) terms as Home Media. When researching photographs of the same era, it was quite disappointing to find that colour printed ones were definitely faded, to the point that they would be useless in a chromatic comparison. And as this study wanted to focus on colour, they were discarded, as a comparison item. The decisive, final, point for choosing Super 8mm home movies was Kodachrome, the same type of colour transparencies used. For the purposes of the research four random transparencies were chosen and compared with four random film stills, all from the said collection.

In the study's chromatic comparison, the help of the visual tool Image Color Summarizer was employed. The report contains the average, median, minimum and maximum of each component of RGB, HSV, LCH and Lab. Average hues are calculated, by using the mean of circular quantities. Some of the questions this tool can answer are what the average colour hue, saturation and value are in an image, the colours which are most representative of the image, the image's human readable colour description. The process contains a concise visual information table, which allowed easy comparison of the images we had chosen to experiment with.

The figures which follow (3 to 12) are the study's attempt to find the chromatic relations. The tables (1-3) which follow, visualise these relations, with the help of the abovementioned software. It must be noted that both the home movie stills as well as the transparency images have not been tampered in any way.

Figure 7 Film still from home movie (1972-1978), from the researcher's collection & colour attributes and analysis utilising Color Image Summarizer

Figure 8 Film still from home movie (1972-1978), from the researcher's collection & colour attributes and analysis utilising Color Image Summarizer

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Figure 9 Film still from home movie (1972-1978), from the researcher's collection & colour attributes and analysis utilising Color Image Summarizer

Figure 10 Film still from home movie (1972-1978), from the researcher's collection & colour attributes and analysis utilising Color Image Summarizer

Figure 11 Lourantos J (photographer) (mid 1968). Greek-American family, on holiday, posing at the Parthenon, Athens, Greece [transparency] (from the researcher's collection)

Figure 12 Lourantos J (photographer) (1973). Boy in Royal Botanic Garden, Sydney, Australia [transparency] (from the researcher's collection)

Figure 13 [1] Lourantos J (photographer) (early 1968) Neil Street, Harden, NSW, Australia [transparency] (from the researcher's collection)

Figure 14 Lourantos J (photographer) (1967) East-West Airlines DC-3 aircraft in Harden airport, NSW, Australia (racecourse field) [transparency] (from the researcher's collection)

Random colour comparison of transparencies and the 1960s palette				
Closeness percentage	**Image number**	**Name**	**Hex number**	**colour**
86%	6	mountbatten pink	#9F7F90	
	16	double haystack (natural)	#CFB285	
84%	3	emperor	#53474C	
	16	hawaiian tan (teak)	# 995B17	
89%	6	torea bay	#3D4179	
	16	teal blue (blue mustang)	#2F768D	

Table 2 Colour palette of figures 5-12

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Selective colour comparison of figures 3-10 (random picks)					
Closeness percentage	**Image number**	**Pixel density (%)**	**Name**	**Hex number**	**colour**
95%	3	20,52	emperor	#53474C	
	7	16,26	zampezi	#635153	
81%	4	18,23	mountbatten pink	#9F7F90	
	7	28,50	brandy rose	# B2B977	
89%	4	36,78	scampi	#5E5AA2	
	10	27,49	wave rider	#4B4276	
84%	5	14,57	masquerade	#6B7EB6	
	10	32,21	sky diver	#4D82CF	
84%	6	27,10	torea bay	#3D4179	
	9	8,65	downriver	#0F1F51	
95%	6	18,55	silhouette	#2B242D	
	8	10,10	celestial blue	#0C1D30	

Table 3 Selective colour comparison of figures 5-12 (random picks)

After acquiring the colour data from the images (Table 1), the next step was to compare random colours from the chromatic palettes generated. The use of the Color Matcher tool from the Color Tools webpage (http://www.colortools.net/color_matcher.html) was chosen, allowing one to draw very interesting conclusions, since it compares given colour relations and produces a closeness percentage (Table 2).

The results show us that there are definitely aesthetic colour relations. In both the colours are similar, though not identical. This is something expected. Both transparencies and film stills are part of the eras' chromatic palette. In all cases we have colour relation results ranging between 81 to 95%. The percentages are high because the colours are closely related, but the aim was not to find the precise same colours but their aesthetic relation.

The extra step

The claim that the colours compared are part of the era's palette seemed to be an overstatement. What was needed was a comparison with other material. This is quite challenging as the standards of the chosen studied material were carefully controlled. Yet there must be a way to find the broader palette of the times. In Juicebox Interactive's site (https://juiceboxinteractive.com/blog/color/) we found such a database. They claim they have captured the colours of the last 100 years. The two chosen palettes were, of course, those of the 1960s and 1970s.

Figure 15 Images used for producing a 1960s colour palette. Retrieved from https://juiceboxinteractive.com/blog/color/

The simple, six-colour, palette produced for the 1960s is given below:

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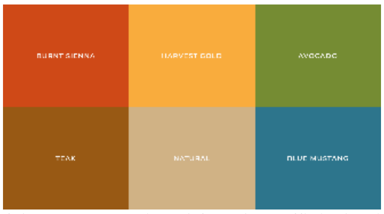

Figure 16 Colour palette of the 1960s. Retrieved from https://juiceboxinteractive.com/blog/color/

The 1970s palette is this:

Figure 17 Colour palette of the 1970s. Retrieved from https://juiceboxinteractive.com/blog/color/

In order to gain all the information of the palette a total of seven colours was chosen during the usage of Image Color Summarizer. This was done as we have a six-colour palette plus the lettering in them. The results of the analysis are given at the figure below:

Figure 18 Results of the 1960s palette colour analysis & colour attributes and analysis utilising Color Image Summarizer

Then by employing the Color Matcher Tool, as done before for the transparency and home movie comparison, we may look for colour relations between transparencies and the 1960s palette. The results are shown in the following table:

Random colour comparison of transparencies and the 1960s palette				
Closeness percentage	**Image number**	**Name**	**Hex number**	**colour**
86%	6	mountbatten pink	#9F7F90	
	16	double haystack (natural)	#CFB285	
84%	3	emperor	#53474C	
	16	hawaiian tan (teak)	# 995B17	
89%	6	torea bay	#3D4179	
	16	teal blue (blue mustang)	#2F768D	

Table 4 Selective colour comparison between the 1960s palette and random transparency colours

Although only three colours were chosen, of the total six, the fact is that the chromatic relations range between 84 to 89%. The colours of the transparencies correspond, closely, to the chromatic palette of the era. At this point we feel we should point out certain facts about the final comparison. Yes, it is random and the palette seems to be representative. Yet we are not very sure about the amount of data collected which produced the palette. But it does fall inside certain parameters: the data is diverse and ranges from actual photographic images to, carefully designed, movie posters. The overall feeling produced is quite convincing.

Conclusions

Our study tried to approach transparencies through their eclectic colour relations with the colours of its era. Our research proved that this is true, by employing colour analysis and software comparison. Thus, these methods can be used as a helping tool to researchers who have no information about their images. Transparencies were a medium for their era. The practise of using transparencies, instead of printed photographs, is a rather important factor, and not only to the photographers themselves. It moves them from pure photographic items to the testament sphere and they consequently become part of family history archives, much like paper printed photographs. But it is their colour and presentation which sets them apart. The slide show transforms them into something akin to movie film projection, even though there is no actual movement of the images -apart from their succession. Film and transparency presentations are, almost, identical. They feel as a continuation of the silent film era, which itself was a step away from the magic lantern or phantasmagoria shows. They were, like all photographic images, a glimpse in Time, but they were colour ones, when colour was scarce. Their saturated colours and contrasty makes them almost a pop image. And pop is a 1960s and 1970s byword, being all the rage in the cultural scene, both in the public as well as the private fields. Our belief is that as some elements of the transparencies are, usually, missing that does not stop us from studying them as images, same as if they were negative film printed ones. Subsequently, after this small-scale empirical case study conducted, we have reached the supposition that transparencies should be labelled as a communication device, with a social interaction angle, but furthermore they ought to be considered as cultural items, with invested metadata and emotional impact. Transparencies are a novel item in the field of Visual Culture but we feel confident that more will try their hand in contributing to their study.

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Serial and geopoetic architecture of the territory, indexed color at the service of enhancing a vernacular heritage.

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Abstract

Through several distinct examples, from the working-class architecture of northern France to the seaside architecture of the northwest, we will question the place of color in the neighborhoods of serial architecture and the way in which the chromatic index takes all its meaning in the singularity of the buildings in relation to each other.The inhabitant appropriation by the patterns and the color brings poetry and enhances the streets while playing with this unique seriality with often asserted styles.The proposed trip through France will pass by Tourcoing, the city of a thousand chimneys and Saint-Valéry-sur-Somme, the beauty of the north. Inviting to a poetic reflection on the place of color as an interstice, as an index, as a punctum in the sense of Roland Barthes, will be the heart of the talk.

Keywords: color plan, serial architecture, color appropriation, social uses.

Introduction

The study will be approached through field surveys and archival media, documentary films and literary media and varied documentation, in order to understand how serial architecture can, little by little, emancipate itself from typological similarities and monotonous streets to find its place through a few clues that make it unique.We will discuss the way in which this subtle game between resemblance, belonging and singularity, allows these neighborhoods to retain their DNA and their attractiveness over time, from the point of view of the perception of the visitor, the passer-by, but also from the point of view of the inventory of heritage and the preservation of architectural styles.

1. Case study number one: Tourcoing, textile city and inhabitant appropriations

The territory explored is centered on a city in the north of France, Tourcoing. The North has been, for us, in recent years, a field of professional study, within the framework of the realization of chromatic charts and master plans of coloring for architecture. We then explored, as colorists of Nacarat Color Design, Amiens, Tourcoing and Lille, industrial cities of the textile trades, whose hegemony is located in the 18th and 19th centuries.A work of surveys, notations and historical research on architecture and human and industrial history has been carried out there, with, of course, color at its center. From the observation of places, silent witnesses of shared cultures, what clues can help to understand the local chromatic history? What types of interconnections can be identified between industrial coloring practices and resident appropriations?

1.1 History and heritage

The architectural history of the city of Tourcoing has always been closely linked to the development of the textile industry. Although since the 15th century Tourcoing has already been exporting sheets to Russia, the birth of textile production seems to have its origins in Lille. Indeed, Lille, which, from the 17th century, had the absolute monopoly of « sayetterie » (weaving of pure woolen fabrics) was subject to strict corporate regulations. Merchants, in order to escape these laws and pay cheaper craftsmen, seek workers in rural areas and therefore turn to Tourcoing. Textile work requiring little equipment, workers work from home. The habitats are therefore lowered in relation to street level, and the openings rarefied, in order to favor in the work rooms, called "workrooms", the humidity necessary for the handling of the textile.

We can still see some examples of these house-workshops today in the surrounding countryside of Tourcoing.

When the city changes again, it is always related to textiles. Indeed, to successfully compete with the Lille monopoly, merchants from Tourcoings produced bourgeterie (wool is mixed with linen, silk, or cotton), then pure cotton. While in 1789, Tourcoing concentrates 4/5 of the combers of the North, it is the work of cotton which will introduce the beginnings of the industrial revolution. Cotton, a tougher and more elastic material than wool, requires more labor and is therefore expensive. The merchants then adopted the Mull Jenny, the spinning machine, which had just been invented in England, and the urban landscape changed: the workers were gathered in workshops built at the edge of the water (wells and aqueducts were added to the urban landscape) in order to optimize the operation of the new steam engine. Slowly, with mechanization, the city is changing. The factories appear, always associated with workers' housing, small identical and adjoining individual houses, either behind them or in the middle. The Tourquennois resumed the production of wool, until declaring themselves, on the occasion of the international exhibition of textile industries of 1906, "the most considerable wool center in the world". Demography is exploding, and wealthy bosses are settling in the center, around the new Town Hall, on the new grand boulevards. Inequalities are widening between rich and working-class neighborhoods, whose insalubrity will repeatedly alert the municipality and urban planners. Today, after several sanitation and extension plans, until the creation of the Lille-Roubaix-Tourcoing conurbation, a new energy is taking hold of the city both in terms of business creation and redevelopment of the architectural heritage of Tourquen.

The polychromies of facades, on workers' housing today have their singularity: they are multiple and varied, and yet, follow and resemble each other. The working-class housing, the « corron », the « courrée », are its symbols. In their first morphology, they look alike, but over the years, they are subtly colored, some inhabitants having appropriated their habitat.

The glazed bricks on the ornate facades in Tourcoing

The glazed bricks on the ornate facades in Tourcoing, rue des Ursulines

These small low houses in whitewashed brick appear from the 17th century in Tourcoing and in the surrounding countryside. They are simple ground floors, aligned in rows or grouped in courtyards or courtyards. At the time, combers or spinners worked from home. Their habitat was often associated with the factory and the merchant's house.

Between 1835 and 1850, another type of habitat appeared, which is still dominant today: that of the simple workers' houses on one floor, higher than the small houses which predominated previously. They are aligned in rows on a principle of repetition or symmetry.

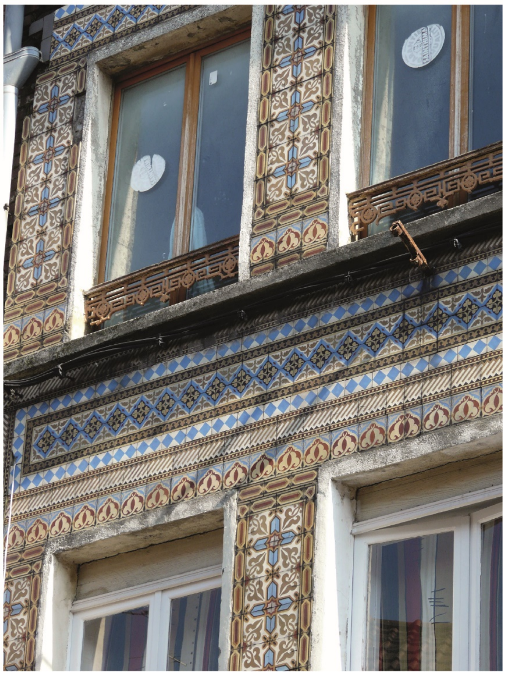
False windows sometimes punctuate the facades, in an aesthetic desire to give a singular breath to the too great regularity of the facades. At the time of construction, the brick is whitewashed in white, brick color, or left bare. One or two strips are present on the facade and glazed bricks are placed on the door lintels, on the strips, or dotted on the facade.

1.1 Inhabitant appropriation

Based on our studies, cited above, our surveys and duplicates, and our immersive look, we try to understand the plastic link that is created between the space of the facade and the space of the textile sample, produced at the same period as these colorations. We then look for their chromatic and aesthetic similarities.

The big question, what relationship did the inhabitants have to color? How and why serial facades have gradually been dressed in more individualized colorings, exploring color in multiple ways? What type of color culture was transmitted then? What relationship to memory and its transmission in this chromatic appropriation?

Reappropriation of inhabitants, Tourcoing



Colour, as we have seen, was part of everyone's daily life, and the patrician residences, the houses of the merchant, of the engineer, bore within them all the characteristics of an increased interest in architectural colour.

What then for the worker?

Our field approach does not aim to constitute an anthropological approach strictly speaking, but rather to create links between aesthetics that move from pattern to architecture. Weft, placed patterns - floral patterns, stripes, all-over patterns are all marks of a style, an era, a probable appropriation between a historic textile culture and its urban echoes.

2. Case study number two: Saint-Valery-sur-Somme

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The town of St-Valéry-sur-Somme is located at the mouth of the Somme which forms a vast bay open to the English Channel. This space offers changing views with the tides and alternating seasons from the city, marine, urban and rural views.

The Bay of Somme is listed as a UNESCO World Heritage Site and is part of the club of the most beautiful bays in the world. This magical and wild destination is a real ornithological lung for the region.

1.1 History and heritage

In Roman times, the site raised on a spur over the sea defended the mouth and a rear port placed on an indentation of the southern shore.The legend tells the existence of a city in the 5th century located under the medieval town.
The tenth century saw the birth of the abbey located near the enclosure (some remaining vestiges are later) of the fortified city. The rest of the enclosure probably dates from the 15th century, a time of intense modifications to the habitat and the church where the masonry fittings became characterized by a checkered pattern of stones and flint associated with wooden panels.
The district of La Ferté experienced a real boom from the 16th century. The fishermen's dwellings, very modest, developed along the bay, to which were added bourgeois residences of shipowners in the 17th century and two shipyards. The plots are deep. The house of the shipowners and population linked to this activity of trade, customs, is on the facade with brick and stone panels, the annexes developing perpendicularly in depth and adjoining.

The dwelling in the upper town continues to follow the fashion of a regular layout with transom and mullioned windows.The importance of the city will double from the end of the 18th century when the dam towards the Somme was created.

The beauty of the marine landscape mixed with the charms of this small town will not leave indifferent the few bourgeois who had beautiful secondary residences built there at the end of the 19th Century at the edge of the water along the bay.

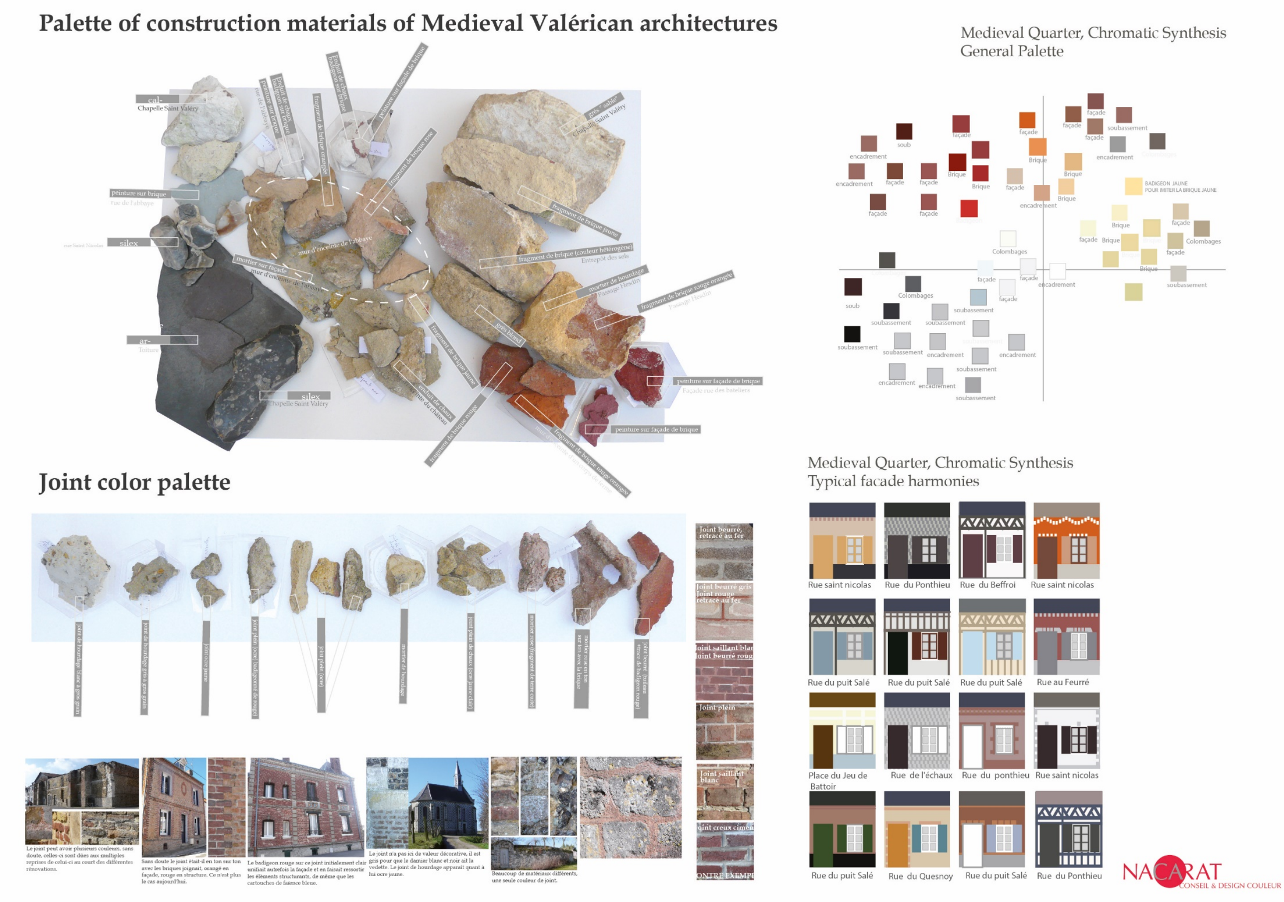
From the new vocation of these seaside towns are born new equipment linked to new activities, swimming, nautical activities and sailboat regattas.

1.2 Inventory of colors and materials of Valérican architectures by identified perimeter

As part of the construction of a ZPR (heritage protection zone, abandoned project) in 2010, chromatic statements of the facade, district by district, were carried out by Nacarat Color Design.

Trying to understand the identity of the city as a whole (from the medieval town to the seaside town), historical jewels of the city, we will look here at the sailors' quarter and its evolution over time.

a.The medieval city: in the heart of the medieval city, during our surveys, few things seem to have changed from the point of view of the colors and materials present in the district. Although the erosion of the bay and the living practices of the city have greatly evolved, there is nothing to suggest that there has been a major evolution in the palettes of colors and materials in this territory of the city. This area testifies to its past and magnifies its materials, and in particular the half-timbered facades and the flint fittings.



b.The seaside town: the "seaside town", consisting mainly of architecture in eclectic styles, remains a special space in Saint Valéry. Indeed, it is linked to the emergence of the leisure society and corresponds to one of the "best" times of the city. This area offers a historical look at past tourist practices. The architectures located along the quays, by their position, seek to highlight the view of the bay: thus certain structural elements of the facade are modified: the windows are wider on this side, the entrances buildings are built on the bay side… A sumptuous setting for exceptional villas that "parade" along the promenade.

c.The sailors' quarter: the sailors' quarter, relatively closed in on itself, with narrow streets, is a quarter which has forged its own identity and which still exudes the life of yesterday. This wealth, initially built around the small trades of the sea, seems to have persisted over time and survived the disappearance of the fishermen in Saint-Valery. However, the current polychromies, noted in the field, are not very present in the historical pictorial testimonies of the naturalist painters of the region, who leave us a testimony of a certain chromatic sobriety. Is it linked to a lack of interest on the part of painters for the most humble populations of the city? Is color as we discover it today linked to contemporary practices that appeared later?

Was the notion of decor already present through folklore linked to sea trades? (indeed, miniatures, fishing nets and other utensils often dry outside the facades...)

On the ground, today, the less colorful facades are little valued. They visually disappear behind this dapper polychromy. The liveliness of the colors leaves no room for more nuanced chromatic expressions.

The polychromy present in the sailors' quarter today carries the spirit of the place. In a certain creative freedom, sometimes not very harmonious but full of diversity, the small houses of the district carry the personalities of their owners. This practice, of which few pictorial testimonies of the time mention it, seems to be a relatively recent practice.

Change of material, historical lime to film-forming paint: our field surveys show facades that are often white and colored whites, to which are added colored paneling in almost every color.
The detail elements are also very colorful, with even more assertive, more saturated colors and they are complemented by its traditional black bases.
Today the majority of brick constructions, from the 18th to the 20th century, whether it is the small fisherman's house, the rural habitat, the town center building or even the seaside villa, use a film-forming paint on the facade.

Research on archival documents shows that lime was once very commonly used via whitewash to sanitize and protect facade bricks. This practice was above all characteristic of low-income housing. The whiteness of the lime therefore often illuminated the facades, and the use of pigment was intended for rather bourgeois facades.

Today, film-forming colors have multiplied to respond to a purely decorative function, causing the loss of the original identity of the building.

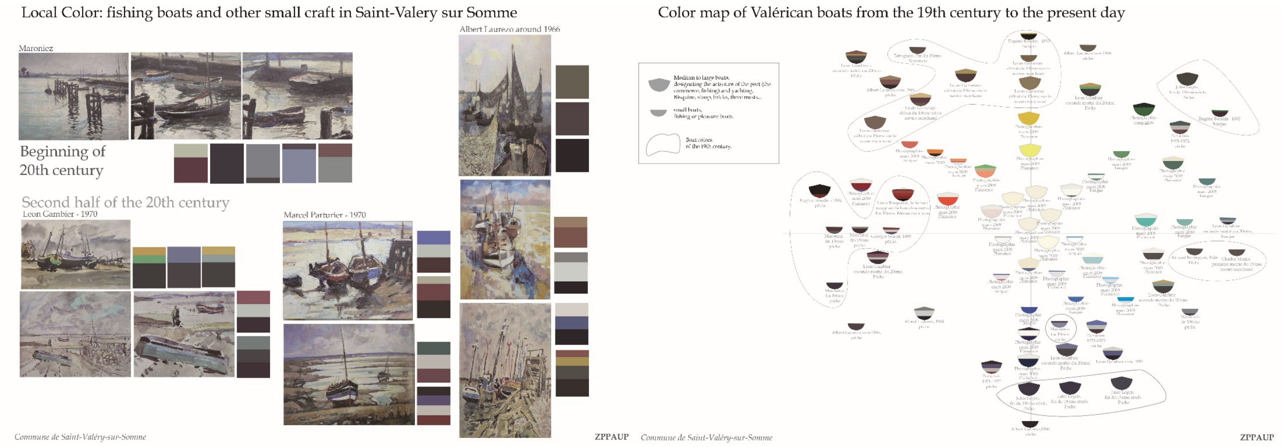
2.2 Half-timbering, an ancestral construction method and a pastiche aesthetic:

The half-timbering is made up of a wooden frame whose voids are then filled with turning made of various materials: torchi, plaster, raw or baked brick, flint, sandstone. It is the structure of the building which, initially carrying, then dresses the facade with its very characteristic writing. Patterns adorn the entire facade or only the corbelling, the gable. The fat lime rendering covers the turning and contrasts with the color of the wood (usually oak), which is often dark, highlighting this facade decoration, crossed, parallel, in a diamond shape. These geometric designs often have a meaning. This tradition was relayed during the 20th century by a summary imitation: painted strips cover the facade, sometimes using wood tones, sometimes completely innovative with shades of blue, green or red. These false half-timberings are slightly protruding, they are also ribbed like wood, the assembly pegs are also restored in the form. A way to ennoble the building, to give it extra soul and style. However, it is interesting to note that this style, initially characteristic of a rudimentary construction method, became one of the emblematic representations of the seaside town. As it evokes both the splendor of seaside villas and the picturesque medieval.

These statements are representative of the pluralities of color expression in Saint-Valéry-sur-Somme, between tradition and modernity. Wood tones are very present in the abbey district, in the medieval town, on the port (quai le joual, Perret, rue ravin and Anguier du peuple). The deep tones of emerald green structure and sophisticate the old facades of the medieval town, they make the red brick of the abbey district vibrate, the white wash contrasts with their depth. The range of blues is very represented in the lower town. Yellow greens are found in all areas of the city. The luminous and very pure color of almond green stands out from the rest of the palette, as do the intense indigo blues which pulverize the delicate shades of the other colors. A range of bluish gray prints the touches of light on the whole city, accompanying in turn the small fisherman's house, the shipowner's house, the city building.

2.3 The colors of the boats, another sign of the change

A color chart has been produced, it is a representative synthesis of the chromaticity of the boats of Saint-Valéry-sur-Somme. It confirms the changes in the uses of color in the city, on the coloring of boats, from the 19th century to the present day. Maritime activity is emblematic of the bay, a very strong vector of identity. In this, it may be a testimony of major interest in understanding and completing what can currently be read about the built landscape of the town.



In the 19th century, the entire flotilla and large-scale boats plying the bay were predominantly brown and black in color. The nuances are numerous and characteristic of the wood material but also of the tar used to seal the hulls. The sails are of light tones even if wood or brownish tones are sometimes encountered.

In the 20th century, the colors diversified and intensified. The wood tones are almost absent, due to the change of materials for the construction of the boats. The care taken to seal wooden boats is no longer suited to current hulls, which are constructed from various materials such as steel, aluminium, ferro-cement or fiberglass reinforced composites. The fairings are no longer subject to the limited color of the wood material and therefore adopt multiple colors. The small boats are often very bright, from orange to red to turquoise. Pleasure boats from 10 to 15 meters display immaculate white hulls. These boats can be seen from afar. They impress the landscape of the bay in a more violent way than the old wooden boats.

Thus we can ask ourselves the question of the link which today unites the practices of color on the flotilla and on architecture.

Because we know that a link did exist between the two supports: the "black" color, that of tar, was found on the foundations of rural houses, fishermen's dwellings, for the same reasons as for boats: protection and waterproofing. Currently, the polychromy of the boats, just like the white, are the expression of the mutations of the activities related to the sea and those of construction technologies. These changes can be read on the facades of Saint-Valéry, particularly in La Ferté and in the Court Gain district, as if in a "natural" way, the broken link with the ancient tradition of fishing and activities related to fishing of the sea, had to be revived by color to reunite the sea again with the city.

Conclusion

Contrary to the bourgeois and style façades that can be encountered in the same territories (mansions in Tourcoing, bourgeois houses, eclectic-style pleasure boats in Saint Valery), the practices of inhabitant appropriation dispense with noble materials and decorations calling on the skills of craftsmen. It is often color, and color alone, that saves, personifies, embellishes and allows appropriation. The second skin, second work, film-forming paint or whitewash, is therefore the first way of personifying. Then comes the facing material, such as cement tile or tiling, and finally the plants, the flowers on the facade, then the added decorations, the ephemeral colorings, the ultimate ornament, which make up for a lack or pastiche and echo a trade, a story, a belonging. In Tourcoing, it is the decorations of the mansions, where the glazed bricks, but also the inspirations of a textile richness anchored in the territory, are evoked on the serial facades of the small « tourquinoises ». In Saint-Valéry, a story with the sea, and the color that dresses the boats came to dress the houses of sailors and imitate and color, then reinvent the historic half-timberings (These two very vast studies have been sketched in this article, they are the subject of more in-depth research, in other seaside and industrial areas).

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Quantifying color in culture: color trends in Italy (1960 to 2020) through album covers

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Abstract
Color trends are commonly discussed qualitatively and argued inductively: supporting evidence is selected by writers, then expanded into a universal theory ("*these [objects] are why [name]* is the color of the season"). The pervasiveness of color and the writer's arbitrariness of choice make it difficult to scientifically prove these claims. This paper offers an alternative solution by quantitatively mapping out color usage through archival analysis. Yearly time series data, mapping color usage over time, was produced by analyzing album covers released in Italy from 1960 to 2020.
Five trends were identified: (1) colors commonly found in nature exhibit stabler usage over time compared to infrequent colors; (2) the increase or decrease of certain colors directly impact the usage of others; (3) orange-brown and red were the most popular colors of the late 1960s and early 2000s; (4) light blue emerged significantly in the early 1980s, to then decline in the late 1990s; (5) ultramarine blue and purple surged in popularity in the late 1990s, then faded rapidly in the early 2000s;
Our study is significant for multiple reasons: our methodology provides new ways to understand color using existing digital archives; qualitative statements on color can be revised and supported quantitatively; comparisons between archival analyses can lead to sociological understandings of color beyond traditional literature; academics and artists can better understand color using data-driven research.

Keywords: color analysis, data science, color trends, album covers.

Introduction

In popular culture and press, color trends are often presented and argued qualitatively. Items of clothing, artworks, textiles, interiors, and more are instrumentalized by writers in support of their observed trend. Once an ostensible color trend is recognized, more evidence is collected to support it. Culture writers are not typically required to utilize scientific methods or data analysis tools. Their arguments, based on a limited selection of items, have been considered sufficient in the face of an infinite pool of colorful objects.
On the other hand, qualitative discussions on color may encounter limitations based on foundational criticisms of this type of analysis: being too subjective (Bryman, 2012), prone to selection bias (Collier, 1996) and proposing theories valid only insofar as the sampled evidence (Popper, 2014). These issues, in relation to color writing, have been highlighted below.
In the New York Times' article "*In Watches, Green Has Grown Into Favor*" (Swithinbank 2021), the author interweaves conversations with psychologists, product managers, and heads of sales corroborating an incoming "green watch" trend. The analysis style is distinctly qualitative, producing a pleasant and comprehensible article. On the other hand, the number of evaluated sources is limited: a broader quantitative survey would have produced a far more objective, "bigger picture" evaluation — which may or may not have substantiated the author's claim. This selective approach to evidence is seen throughout literature and popular books on color.
Michel Pastoureau's book series "*'Black' 'Green' 'Blue' 'Red' 'Yellow': The History of a Color"* (Pastoureau, 2009; 2014; 2017; 2018; 2019) maps out single colors similarly to Kassia St. Clair's *"The Secret Lives of Colors"* (2017). Yet these books, including the New York Times article, all base their arguments on established qualitative literature. The effective manifestation of color in society isn't recorded nor measured.

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This research paper generates a quantitative, historical overview of color usage. This was achieved by color analyzing a digital archive consisting exclusively of album covers. Album covers, also known as “Cover Art” or “Album Art”, are an excellent historical sample as they are time-stamped and represent the yearly color choices of graphic designers and artists. This was inspired by the principal author’s recognition of a strong usage of light blue in 1980s Italian album covers.

Research Method

<u>Data Set</u>

Discogs.org is an online, crowdsourcing music database, featuring thousands of music releases (Discogs.org, 2022). Using a custom Python script, album covers in Italy from 1960 to 2020 were extracted from the website, separated in folders by year. 12 web pages containing 250 album covers each, sorted by “Popularity”, were used to download album covers for each year.
Duplicates were found and removed using two software applications. Gemini 2 (MacPaw Inc., 2016) detected and deleted visually identical files, while PhotoSweeper (Overmacs Team, 2011) detected and deleted identical, but slightly deformed album covers (because of aging and/or capturing artifacts). From the original 158,812 covers downloaded, 147,358 unique covers were used. Releases that include the same image but include different album information (considered “single” releases) compiled in Figure 1 were not deleted. These are not duplicates but individual releases, which happen to share the same image.

Fig. 1 – Collage of individual releases from the same artist (Milva), early 1960s.

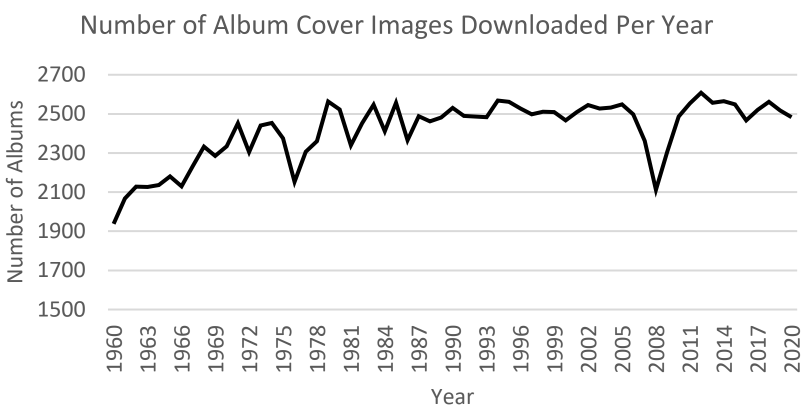

Fig. 2 - Number of images downloaded per year.

Data Analysis

Color	Hue	Saturation	Value
Red	>355 or ≤10	0.3-1	0.5-1
Red-Orange	>10 & ≤20	0.3-1	0.5-1
Orange-Brown	>20 & ≤40	0.3-1	0.5-1
Orange-Yellow	>40 & ≤50	0.3-1	0.5-1
Yellow	>50 & ≤60	0.3-1	0.5-1
Yellow-green	>60 & ≤80	0.3-1	0.5-1
Green	>80 & ≤140	0.3-1	0.5-1
Green-cyan	>140 & ≤169	0.3-1	0.5-1
Cyan	>169 & ≤200	0.3-1	0.5-1
Cyan-blue	>200 & ≤220	0.3-1	0.5-1
Blue	>220 & ≤240	0.3-1	0.5-1
Blue-magenta	>240 & ≤280	0.3-1	0.5-1
Magenta	>280 & ≤320	0.3-1	0.5-1
Magenta-pink	>320 & ≤330	0.3-1	0.5-1
Pink	>330 & ≤345	0.3-1	0.5-1
Pink-red	>345 & ≤355	0.3-1	0.5-1

Table 1 - HSV Values utilized for this data analysis.

We analyzed a total of 147,358 images. The number of images per year ranged from 1938 to 2608 (see Fig. 2). The album covers were analyzed with the statistical software R (R Core Team, 2022). A customized script was used to extract the RGB values from all pixels in each PNG image: the R script is available upon request from the authors. The RGB values were converted to the HSV (Hue, Saturation, Value) color space.

To reduce the amount of data and facilitate the interpretation of the results, 16 color ranges were chosen, their respective hue range based on a website specializing in digital color (WorkWithColor.com, 2022). The 16 colors and their respective HSV ranges can be found in Table 1.

The ranges were detected in each album cover image, producing 16 numerical values representing the amount of color (of the ranges) within each album cover. The mean number of pixels for a specific color range, across all albums covers for a year, was calculated. This determined the mean color quantity for each color for each year. When the data was plotted, trends for color usage could be identified. Additionally, a correlation matrix was calculated comparing the color ranges to themselves, identifying any strong or moderate correlations between colors.

Additionally, the coefficient of variation was calculated for each color range. This is the ratio between the standard deviation to the mean. This was used to determine the variability of each color's usage in relation to its own historical mean. This type of analysis reveals each color's historical "trajectory" and "identity" as distinct from other colors.

Results

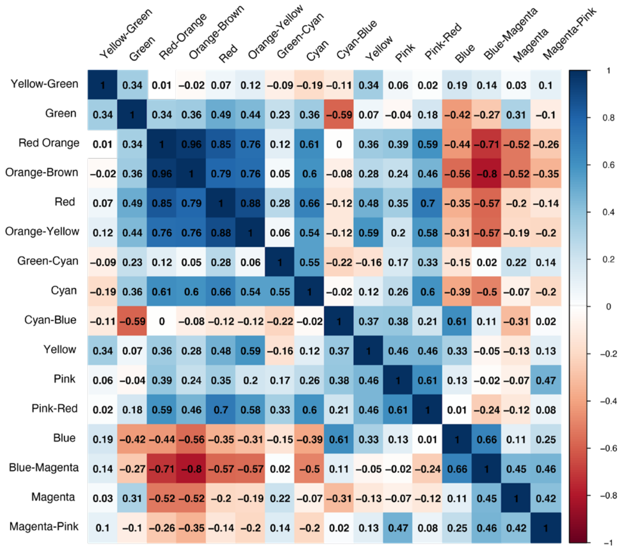

Fig. 3 – Correlation Matrix comparing color ranges to themselves.

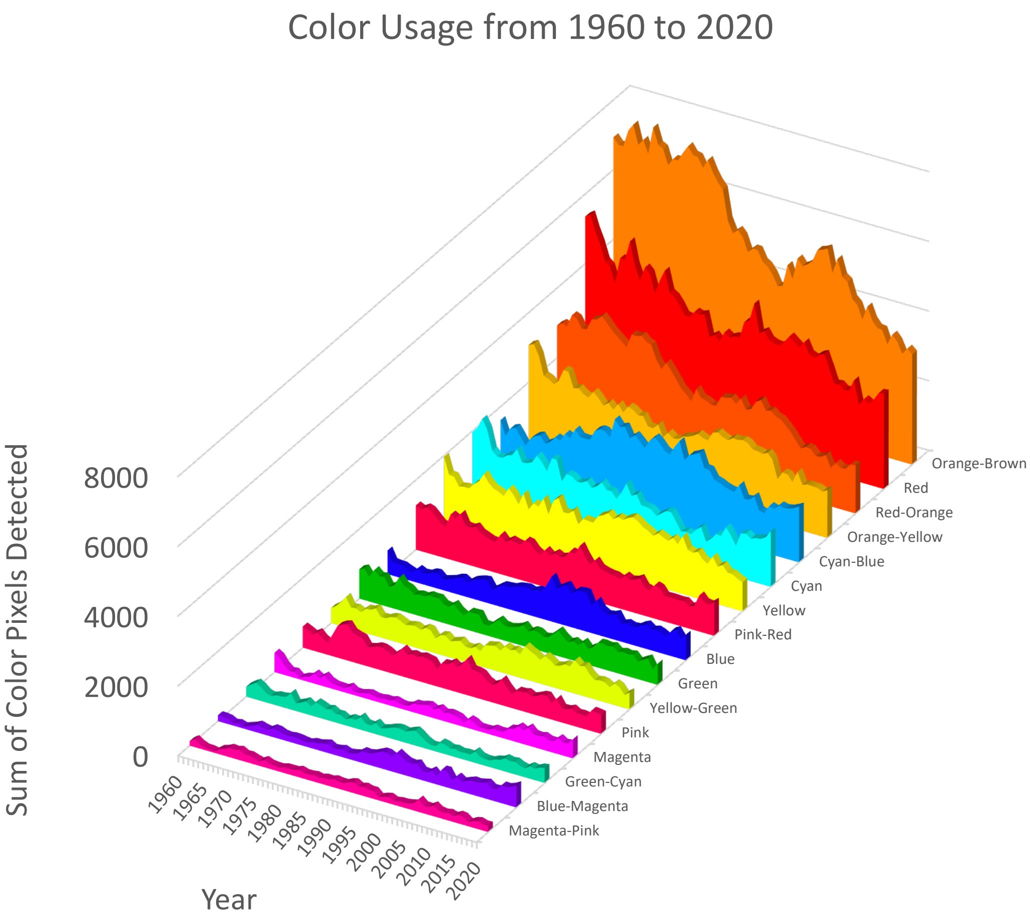

Fig. 4 – Color Usage by year, 3D Stacked View

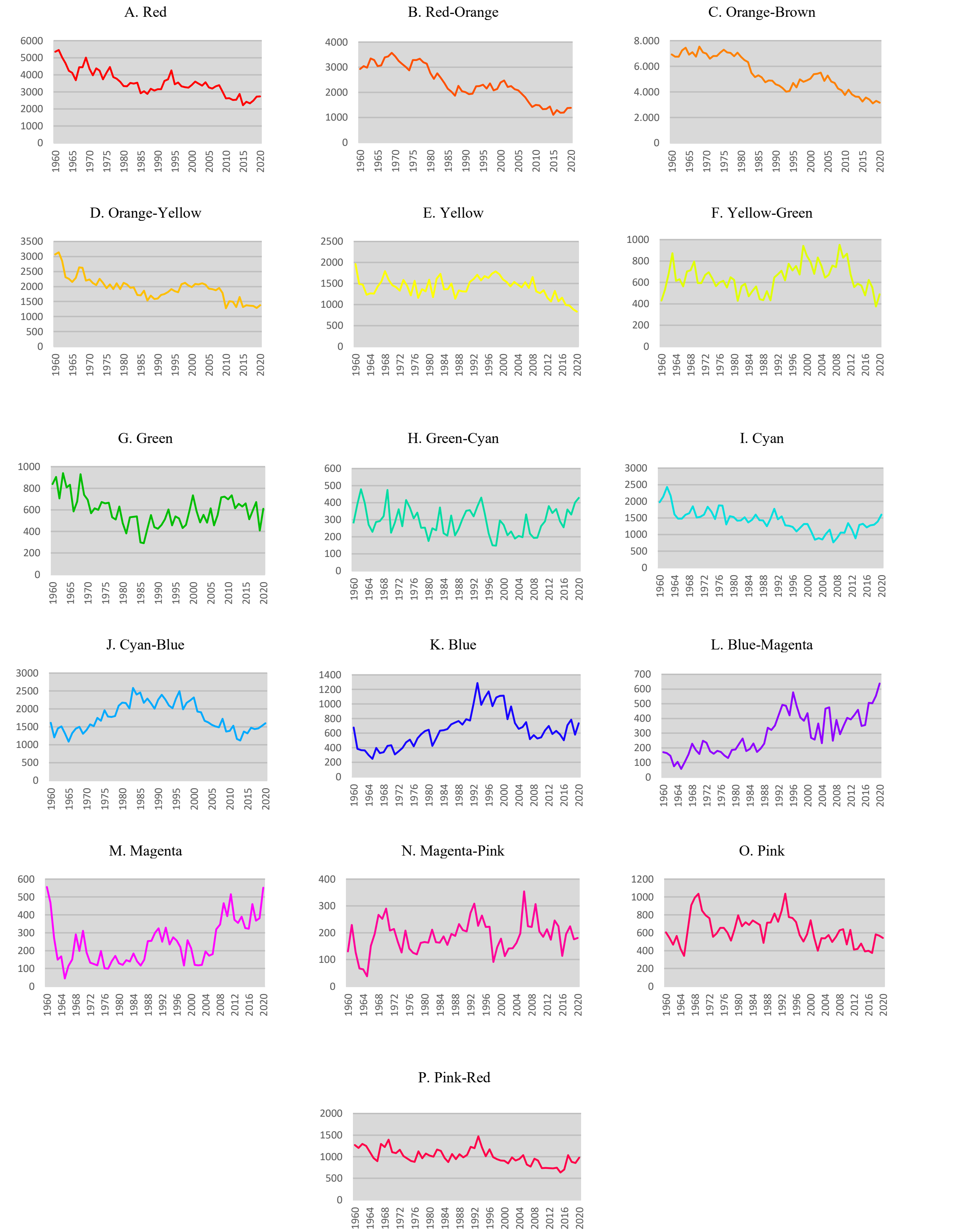

Fig. 5 – Color usage represented graphically for each color range. X axis representing time and Y axis representing number of pixels detected.

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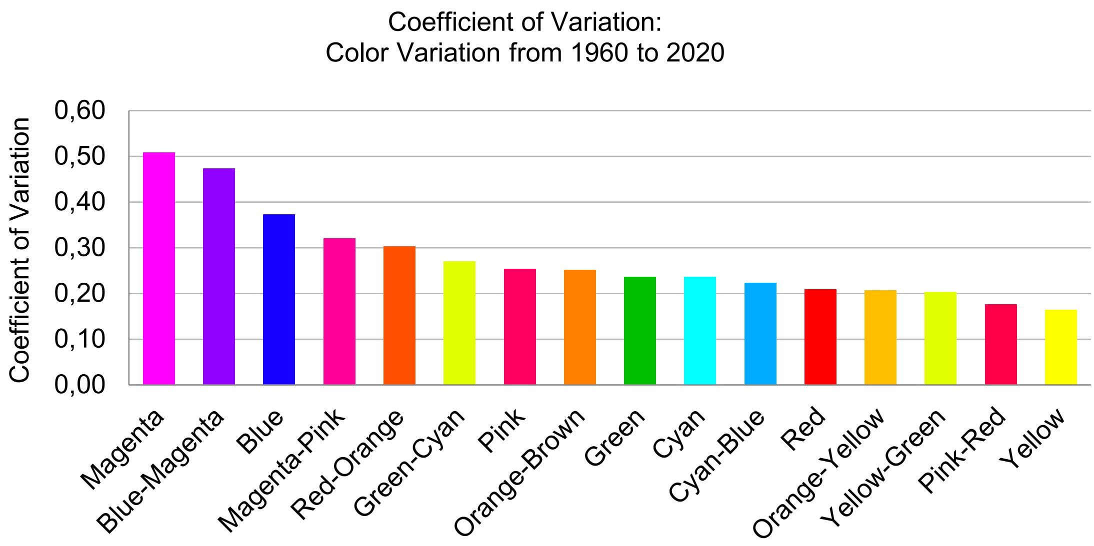

Fig. 6 – Color Ranges by order of Coefficient of Variation

Our findings demonstrate noticeable color trends across all surveyed color ranges. As seen in Figure 4, Orange-Brown was the most popular color of the time range surveyed (surging in the 1960s and then again in the early 2000s as seen in Fig. 5C), followed by Red and Red-Orange. Light blue (Cyan-Blue in Fig. 5J) was a predominant color of the 21st century, rising in the 1960s, plateauing in the 1980s, and decreasing in the 2010s. Ultramarine blue and purple surged in the 1990s, 5–10 years after Cyan-Blue was at its maximum usage. Cyan (Fig. 5I), on the other hand, slowly declined since the 1960s and experienced an uptick in 2008. As seen in Figure 6, Yellow, Pink-Red and Yellow-Green remained stable throughout the years but have slowly declined in usage (Fig. 5E, 5P and 5F).

Moreover, the correlation matrix (Fig. 3) demonstrates how each color positively or negatively impacted one another. Cyan-Blue displayed a moderate negative correlation (R= -0.56) in relation to Green. Purple (Blue-Magenta) displayed a strong negative correlation in relation to Red-Orange (R= -0.71) and Orange-Brown (R= -0.8). Inversely, Red-Orange, Orange-Brown and Red showed strong correlation and affinity to each other. Similarly, Magenta-Pink, Magenta and Blue-Magenta demonstrated similar usage, as suggested by the weak correlations in relation to each other.

Finally, the coefficient of variation demonstrated how each color operates independently in relation to time. Yellow was identified as the most stable color during the 60 years, displaying only 0.16% variance (or dispersion), while Magenta had the highest variability with 0.51% variance.

Discussion

Our study successfully produced time series data on color usage for 16 colors across 60 years, mapping color trends quantitatively and historically. The granularity of our findings allows for original new ways to observe and understand color, producing a series of implications.

The first major implication of our research is in relation to previously established literature. Academically and culturally, color is typically compartmentalized into specific color schemes by decade. The 1970s are known for their brown and natural tones; the 1980s for their saturated and artificial colors; the 1990s for their punk and “grunge” colors etc.

These statements are of course qualitative, and incredibly broad, yet our research supports these quantitatively with yearly accuracy. Orange/Brown and Green were in fact the strongest colors in the 1970s, as seen from Fig. 4, Fig. 5C and 5G. The saturated colors of the 1980s correspond with the rise of Cyan/Blue (Fig. 5J) and later with Blue-Magenta (Fig. 5L) and Blue (Fig. 5K). Red (Fig. 5A), Red-Orange (Fig. 5B) and Orange-Brown (Fig. 5C) peaked in the 1990s, confirming the idea

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of a “grunge” aesthetic. Additional studies on shades of white, gray, and black could further uncover how these colors emerged over 60 years of commercial album cover production.

The second major discovery is in the way we understand colors’ function in relation to other colors. The results from our correlation matrix suggests that the preference or popularity of one color suppresses the usage of another. This is seen with Cyan-blue impacting the usage of Green, and Purple (Blue-Magenta) impacting Orange-Brown. Whether the former affects the latter, or vice versa, these correlations imply tacit preferences in the way individuals select colors (consciously or unconsciously), preferring one color at the expense of another. Moreover, this finding suggests the idea of a preference-based, economy of colors. In this theory, colors are interdependent - some rising and declining together (harmoniously), while other diverge (antagonistically), ultimately affecting one another.

The third major discovery involves the volatility of color trends. The coefficient of variation (Fig. 6) displays how some colors are more susceptible to becoming trends compared to others. Yellow demonstrated the least amount of variability, whereas magenta the highest. This discovery is significant because it can act as a framework to understand color longevity and the nature of color itself. Yellow items might not have seasonal trends or be “in vogue”, yet their perception will remain the same through time since yellow’s usage does not fluctuate significantly. Inversely, magenta might be popular for a specific period, then fall into obscurity. These findings can be helpful for designers who can identify what colors work best, in relation to the longevity of their designed product.

Most significantly, the stabler colors in our findings tend to be those most prevalent in nature: yellow (sun), pink-red (flowers), yellow-green (plants), light blue (sky/ocean). In contrast, the most unstable colors are the saturated, artificial colors difficult to find in nature: magenta, purple, ultramarine blue and magenta-pink. These claims on color would be much harder to demonstrate without a quantitative method of analysis, capable of recognizing color behavior from a more complete perspective than qualitative analysis.

Our quantitative and digital analysis model does include limitations that, while they can be minimized, may have affected some of the results obtained:

1) The prevalence of orange-brown might be the result of two confounding factors: aging paper producing orange tones and skin tone of faces being detected from our script. This could be minimized by digitally removing all faces/skin tone and color correcting the album covers.

2) The color accuracy of the analyzed album covers was dependent on the source; thus, digital covers were more accurate versus scanned or photographed covers (that may contain white balance or calibration errors). A broad saturation range was used to minimize this issue.

3) The Discogs.org archive only includes user uploaded albums, potentially resulting in a *survivorship bias* where only “popular” albums were preserved. The large number of albums sampled significantly reduced the impact of this bias.

4) The color ranges chosen for this analysis (Saturation 0.3-1, Value 0.5-1) detected bold, vibrant recognizable colors, but excluded nuanced colors darker than 0.5 value and less saturated than 0.3. Since some albums might have color accuracy issues, these bolder color ranges generated more reliable results. If more reliable archival data is available, more granular analyses could be conducted.

5) The user-uploaded album covers were processed through Discogs servers; it is hypothetically possible our results reflect inherent compression or encoding settings. This could be corrected by finding additional sources to corroborate the results.

When we compare our results with existing quantitative studies on color, the validity of our research strengths and a theory of color propagation across mediums becomes possible. Our findings strongly align with Francesca Valan’s research, which examines the colors of design items by decade, but increases the granularity and precision of her quantitative color research. In 1960s design, red and magenta were most predominant in design (Valan, 2012); in album covers, red was used most, followed by orange. In 1970s design, Valan found that orange and yellow were the

dominant colors; our research indicates orange as the dominant color, while yellow did not increase significantly. In 1980s design, red and light blue were most prominent, and in our data set, light blue was indeed at its peak popularity at that time. In 1990s design, ultramarine blue and light orange; in our data set, ultramarine blue and light orange also surged in the 1990s. Finally, in 2000s design, light green and dark orange were the most dominant colors, matching our data set perfectly with the high values of Yellow-Green and Orange-Brown. Comparing our results to other quantitative studies builds upon the idea of color as a propagating, sociological phenomenon spread across mediums. With more archives, big data, and data analysis tools, the history of color trends could potentially be tracked from its early stages to the present, across all art forms and cultural products.
Another significant implication with the time series data generated from our research is the possibility of predicting and forecasting color trends. Machine learning could separate specific items from archives (such as fashion items, for example) to historically map out colors in selected objects.
Finally, academics, historians, graphic designers, marketers, artists, and more practitioners of color, can utilize our method and other data driven approaches to perform color choices more accurately, evaluating how they fall in the broader usage in their field.
Our research establishes an epistemology on color and culture based on quantitative archival analysis, forcing a re-evaluation of previously established, qualitative understandings of color.

Acknowledgements
Many thanks to Francesca Valan for sharing her wonderful insights on color and culture. We thank Alexander Levin-Epstein and Shahmir Ali for their feedback, and edits on language and formatting.

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Book of Patterns - an ongoing project

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Abstract

The idea for this project arose in discussions around housing spaces and their importance during the COVID-19 pandemic. The association Schablone works around these topics in an artistic-theoretical manner working on the design of the 'own four walls', by producing an artist's book (sample book of roller patterns), conceived as a limited edition with unique sample sheets.

In the context of craft, art, and space, this project pursues the reappraisal of old craftsmanship in Austria using the example of the almost forgotten technique of the historical roller pattern. This technique was developed around the turn of the century and was initially not completely appreciated in painter circles, but was then used in all areas of the personal spaces in all strata of society until the advent of the wallpaper, which became socially acceptable in the 70s or 80s due to its price. Almost everyone still knows the traditional rolled pattern with its unique color combinations from childhood, such as grandmother's kitchen.

In a mixture of personal memories and experiences, this project explores contemporary ideas and old techniques in a new methodical way. This is accompanied by a collection of samples sheets of pattern from the company Painting Schulz, Melk, and partners.

The project shows the reappraisal of the history of the roller pattern by means of narratives and photographic documentation. The working method on the 'pattern book' started with found objects and parted from the traditional and historical pattern books.

Keywords: pattern, color, material, spatial perception, space

Introduction

Marc-Antoine Laugier and Gottfried Semper detach the wall (the twisted, plaited one) from the tectonic context in which it had fallen since its merging with the stone wall, and see it again as the skin covering the supporting skeleton, the flexible protection the breathing shell or the *Ge-Wand*. In its theoretical research, the surface of the inner wall is only present because of its haptics: From the tradition of braiding and twisting, they derive a human need for a non-monolithic 'residential' wall. Its main focus is on the 'outward' (!) side, the facade, i.e. the face, which has always had the same function as clothing: Representation of one's own attitude and position within a society.

Residential forms such as multistory buildings often no longer permit such an identification for several reasons, and over the centuries the interior has transformed from a private retreat into a symbol of individualistic being and lifestyle. The 'backstage' of everyday life is transformed into the last remaining scene of self-presentation: 'The intimacy of the room then becomes our interiority. (...) And all the rooms of former times can be inserted into this room.' (Bachelard, 1987)

The design of the interior walls, like the furniture, is therefore always a social artefact, as such subject to current fashions and shaped by the respective progress or the available craft and technical means. Two techniques have become established, they have always alternated in the respective trend, but over time also adopted a lot from each other: wallpaper or painted wall? In terms of prestige, the painted wall had to contend with the disadvantage being the 'cheaper' variant - and was therefore not suitable as a distinguishing feature. Nevertheless, the development of both techniques, as well as their changing attribution, was and is synergistically interwoven.

Today, both forms and their diverse variants or characteristics stand for a fundamental decision - one would think: For example, the Bauhaus initially demanded the (painted) 'white wall' without

exception, then propagated clear wall colors to finally produce the famous Bauhaus wallpaper - in a period of 15 years. Thanks to the invention of the stencil and later the roller, the ornament temporarily banned by Adolf Loos has long since returned to our rooms, both on wallpaper and in painting:
'*There are pictures because there are walls. We have to be able to forget that there are walls, and have not found no better way to do that than pictures. Pictures efface walls.*' (Perec, 1999)


Fig. 1,2 – Stairwells, Beingasse & Jägerstraße / Vienna

The roller pattern (Fig. 1,2) replaced the very laborious work of stenciling at the beginning of the 20th century, the idea being to produce a cost-effective, less labor-intensive *wall revitalization*. In the 1970s and 1980s, in turn, wallpaper almost completely replaced the rolled pattern due to its easier handling and fewer work steps. The wallpaper boom lasted about 20 years, during which rolling took a back seat. After a very intense period of color and pattern followed a period of monochromatic wall coatings, which still is preferred today. The demand for wall coating techniques such as pattern rolling is not particularly high, but it is still offered by some specialized painting companies. However, knowledge of the rolling has often been lost, in addition, there are hardly any manufacturers of pattern rollers left. As far as we know, there are still a few in the German-speaking countries, as well as the Czech Republic and Hungary.


Fig. 3 – Pattern rollers in hanging device

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Technic

The pattern roller (Fig. 3) consists of a wooden core coated with a rubber or plastic cylinder, which has a three-dimensional pattern on the surface. There are metal reinforcement discs on the sides with metal pins, serving to fasten the pattern roller in the roller frame.


Fig. 4 – Pattern & foam feed roller within the roller frame
Fig. 5 – Pattern & foam feed roller via roller apparatus

There are two types of pattern roller: the standard roller has a pattern on the entire surface and the ring roller is only partially patterned. There are guide rings on its sides, which on the one hand prevent unintentional slipping off of the unpatterned roller cylinder and on the other hand ensure smooth running during unrolling.
The paint is supplied via a foam feed roller within the roller frame (Fig. 4) or via a roller apparatus with a paint tray (Fig. 5).
Several colors can be supplied to the pattern roller: Depending on how many colors are used, this is referred to as a two-tone or three-tone pattern. A split foam feed roller can be used for this (two-tone or three-tone sponge) to avoid any mixing of the colors.
To apply the roller pattern technique, the first step is to prepare the undercoat and paint it with distemper to cover it in one color. This is followed, for example, by a basic roller as a base and then a single-color cover roller, a two-color roller (two-tone) (Fig. 6) or a three-color roller (three-tone).

Fig. 6 – Pattern rollers and a two-color foam feed roller

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Two-tone means a base roller with one color plus a two-tone roller with two colors, meaning three color-coordinated tones are used (Fig. 7). In the case of a three-tone, four color tones must be harmoniously matched (Fig. 8).

Fig. 7 – Two-tone pattern (three colors) / Book of Patterns

Fig. 8 – Three-tone pattern (four colors) / Book of Patterns

Just like the colorfulness, the type of pattern is of major importance. A repeating pattern after a given length - or a maximum of one rotation of the roller - is referred to as a *repeat*. There are patterns that are rolled either without a match (directionless), with a straight match or with a staggered match. In order to get an even appearance on the wall, the roller patterns must be perfectly aligned.

Use of Color

The original purpose of 'wall revitalization' was complemented by positive aspects of the overlapping patterns and color combinations, traces of usage and soilings were less visible, e.g. in kitchens and stairwells. On uneven surfaces, especially ceilings, the viewer's perception could be optically guided by rolling special patterns with a silky sheen.

The technique was used almost universally in all living rooms in private areas and in social housing, especially in kitchens, because these were repainted about every two to three years due to soilings and durability of the distemper. Living rooms and bedrooms were renewed on average every six to eight years. 'Baroque patterns' (Fig. 9) were often used: e.g. B. with damask background as first and a large pattern with repeat as second layer. The repeating pattern is referred to as a *repeat* (called 'rapport' in the fashion industry), with one rotation of the pattern roller being possible as the maximum repeat. There are patterns that are either seamless because they are directionless (Fig. 10), as well as patterns with a straight or a staggered match.

Fig. 9 – 'Baroque pattern' – historical pattern / Book of Patterns

Fig. 10 – Pattern w/o direction, two layers / Book of Patterns

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In the past, distemper was exclusively used for the application of the roller pattern technique on the wall and ceiling. Most of the rolling was done on distemper bases, but it can also be found on lime paint coatings. Lime substrates had disadvantages due to their high absorbency and very rustic coarse surface and furthermore a different surface feel in contrast to the fine structure of the distemper substrate.
Distemper, a glue-based paint consisting of color pigments, animal or vegetable binders and additives, was still produced in-house by the Schulz company up until the late 1960s.

For the rolling of the patterns, the earth pigments were soaked at the beginning of the work and then tinted in pastel shades with white distemper or with the white pigment Lithopone.
At the beginning of the 20th century, mainly earth and mineral pigments were used. This resulted in a soft colorfulness with a palette of ochre, lemon yellow, ultramarine blue and burnt ochre. All painters had their individual basic colors which they could mix at will. Another possibility was rolling with a satin finish, which could be used for the pattern roller and also as a covering, shiny base - *damask*.
The entire color palette was used for the full-surface application of silk gloss: For this purpose, a prepared substrate is sprayed with damask. The Schulz silk gloss color palette consisted of silver, yellow, pink, blue, gold and copper. This technique was mainly used in representative rooms and bedrooms. Another variant was rolling with silk gloss on colored or white substrates, with white and silver being the main colors.
At the end of the rolling work, a line was drawn, i.e. a line drawn with a ruler and brush forming a border on the wall or between the wall and the ceiling.

Results and Conclusions
Our concept for the pattern sheets is to present a selection of historical patterns in an artistic context. During the arrangement of the sheets numerous discussions arose about classification, categorization and selection of color scheme for the patterns.
Historically, the classification of patterns was based on the type of room: kitchen, living room, bedroom, children's room, stairwell. The colorfulness was soft or kept in pastel tones and matched to each other, even a silk gloss as a pattern or as a damask base was possible.


Fig. 11 – Yellow floral pattern / Book of Patterns


Fig. 12 – Red abstract Pattern / Book of Patterns.

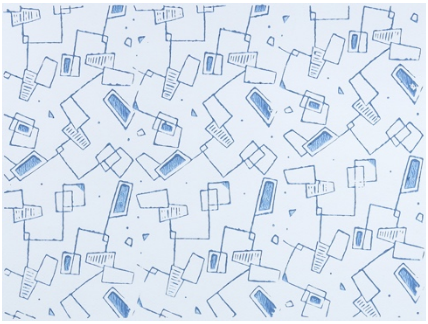
Fig. 13 – Blue geometric pattern / Book of Patterns

This original classification is no longer comprehensible in the current architectural context. On the other hand, artistic research enables new or different paths and directions. The decision was made for a more general classification of the patterns, and so we defined the categories Floral (Fig. 11), Abstract (Fig. 12), Geometric (Fig. 13) and Historical (Fig. 9) for the pattern sheets in an artistic context. With an intense colorfulness of the leaves, we also set a contrast to the original pastel tones.
For the rolling of the sample sheets, we chose the historically customary distemper with colored pigments.

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We show four examples for each of the four categories, which are shown in an unusual color intensity, in contrast to their historical arrangement and colorfulness. The original frame of reference of the patterns is thus dissolved, and evolves of a new, contemporary context, imbedding multiple layers of memory.

Fig. 14 – Historical pattern sheet

The four by four examples of our categories of intense colors along with another four sheets of pattern combinations in historic colorfulness with two to four colors each represent our selection of possibilities. A historical pattern sheet from the Schulz Collection completes as a unique piece each of the pattern books of Schablone, which were manufactured in a limited edition of 33 pieces.

This project is still ongoing, the book of patterns / Collection Schulz is a first summary and research of color and patterns there is still a big potential for research.

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Colours and Daguerreotypes: how to forget colours? « La couleur y est traduite avec tant de vérité qu'on oublie son absence

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Abstract:

Colours and Daguerréotypes : how to forget colours ? « *La couleur y est traduite avec tant de vérité qu'on oublie son absence.* » Is it possible to forget the colours of the nature ? And so, how ? When in 1839, Arago presented the new image, the photography, the *Daguerréotype*, he wanted to promove it…. but this image is achrome ! No lines, no colours ! But it is new, so he could not say : « there is no colour ». He suggested that you can imagine the colours because of the shades of gray…But during these years, in 1839, there is a new method for graving, with colours : the lithography. So how usefull the new image, with colours in the eyes! Is not it to affirm that photography is not so objectivity you can read everywhere ? … Which colours for *daguerréotype*? We propose to search for this question: The articles about the new image in this year 1839, during so few people could look by themselves this image, described the first images they have seen. How? using the words "*tons", teintes, " rapports,"" la tranquillité des masses".* Looking for them: which colours can you see? It is a mirror so you are but dazzled! Therefore how the daguerreotypists could give colours on this plates? During the laboratory manipulations, blue can be present? Fortunately? Girault de Prangey in Greece did all the skies blue! Futhermore, too, little hands could bring colours on each image, each *unicum*! For portraits there are a lot of manuals to do that! So these coloured pictures are not well considered: too easy for a painter: a so coloured picture can it be done but by a bad painter?! New image is not quite a photography yet…So a good new picture is exact, with details, nothing for colours…But for instance there is an extraordinary daguerreotype in colours, in wonderfull colours…the collections of the Museum Ingres in Montauban has this one: is it with the Ingres's pencil ? It is so rare! Why?

But too, daguerreotype may be a matrix for mechanical illustrations… an other thing?

So we propose to study the vocabulary used in descriptions of daguerreotypes during the three years between 1839 and 1841 first. After this point we shall look for coloured daguerreotypes. Which colours are bringed? How? For which uses?

Keywords: colour, light, daguerreotype, polychromy, archaeology, Egypt, Greece.

Introduction

« *La couleur*[1] *y est traduite avec tant de vérité qu'on oublie son absence.* »[2] "The colour is translated with such truth that we forget its absence". When Arago described Daguerre's invention, he suggested the wonder that it would have been for the description of Egypt in Napoleon's time. Colours and daguerreotypes : how can we forget colours ? Is it possible to forget the colours of nature ? And if so, how ? When in 1839 Arago presented the new image, photography, i.e. the daguerreotype, he had to promote an achrome image, without lines nor colours ! He suggested that colours could be imagined through shades of tone, while chromolithography had already shown its possibilities. We propose to investigate this question : which colours for the daguerreotypes ? (Fig. 1-3).


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The articles dealing with this new image in 1839, a year in which few people had a daguerreotype in front of them, describe it using the words "tones", "tints", "ratios", "the tranquillity of the masses". But looking at a daguerreotype is difficult, it is like looking at a mirror : you are dazzled. The daguerreotype may have been the matrix for mechanical illustrations. Moreover, could the daguerreotypists have added colours to the plates ? In later laboratory manipulations, could blue be added since Girault de Prangey obtained all the blue skies of Greece ? (fig. 14-16) But were these images considered ? Would they be too easy for a painter ? And would a painted photograph still be a photograph ? So the good new image must be exact, detailed...

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[1]This text is a part of a PhD that I prepare on direction of Professor Philippe Jockey at ParisNanterre University : *Quelles couleurs pour quelle antiquité ? La polychromie de l'art grec au défi de la photographie d'art, XIX°-XX°s.* See too : Philippe Jockey, *Le Mythe de la Grèce blanche*, Paris, 2013.

[2] Delaroche's words, reported incompletely by Arago : "The process of M. Daguerre proves by its results that it completely satisfies all the requirements of Art and that it carries so far the perfection of some of its essential conditions that it will become for the painters even the most skilful, a subject of observation and study. The drawings obtained by this means are remarkable both for the perfection of the details and for the richness and harmony of the whole. Nature is reproduced not only with truth but also with art. The correction of the lines, the precision of the forms is as complete as possible and one finds there at the same time a broad, energetic modelling, and a whole as rich in tone as in effect. The rules of aerial perspective are as scrupulously observed as those of linear perspective. The colour is translated with such truth that its absence is forgotten. The painter will thus find in this process a quick way to make collections of studies that he could not obtain otherwise than with much time and trouble and in a much less perfect way, whatever his talent might be. When this means is known it will no longer be permitted to publish inaccurate views, for it will then be very easy to obtain in a few moments the most accurate image of any place. The engraver will not only have nothing to fear from the use of this process, but will also be able to multiply the results by the means of his art. The studies he will have to engrave will be of the greatest interest to him. He will see with what art nature is rendered, the colour is interpreted. He will undoubtedly admire how the finish of an unimaginable preciousness does not disturb in any way the tranquillity of the masses and does not harm in any way the general effect. In short, the admirable discovery of M. Daguerre is an immense service to the arts. Quoted in Paul-Louis Roubert, *Introduction du modèle photographique dans la critique d'art en France*, 1839-1859, 2004, p.64.

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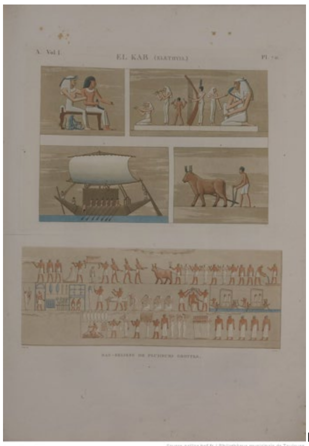
Arago describes Daguerre's new invention

When Arago described Daguerre's invention, he suggested the wonder that it would have been for the description of Egypt in Napoleon's time. The hieroglyphs were translated in 1822 by Champollion, who had died seven years earlier than 1839. In fact the expedition of Egypt : *Description de l'Egypte ou Recueil des Observations et des Recherches qui ont été faites en Egypte pendant l'Expedition de l'armée française*, published by order of the government was edited from 1809 to 1822. In this first edition there are more than 900 plates with more than3000 drawings. A small number of plates were printed in colour using the Comté process [3] for this colourful Egypt. In the first volume of plates from 1809, plate18 (fig.4)


4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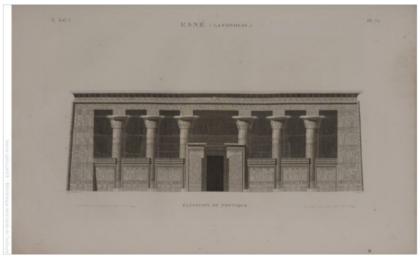
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7

is the reproduction of the architectural colours. The inner courtyard shows the blue sky, a human figure on the left and another in the middle give an idea of the colossal proportions. If the walls are coloured in blue, red and green, the technique can be seen. In the same volume, plate 70 (fig.5) shows a large number of hieroglyphs, but could they be deciphered ? On plate 73 is it different ? Champollion had not yet solved the enigma of this writing. However, since Kircher in 1650, the care that must be taken with these precious transcriptions has not been ignored: precision is claimed. And Caylus in 1752 remarked : "the form, the line and the details of each monument have become my rules ». However, since Kircher[4] in 1650, the care that must be taken with these precious transcriptions has not been ignored: precision is claimed. And Caylus[5] in 1752 remarked : "the form, the line and the details of each monument have become my rules ». Plate 12 of Volume

[3] Pierre Gusman, « « La Description de l'Egypte » (1809-1822) Fonds de la Chalcographie du Louvre », *Byblis* 1929, p. 42-48.

[4] Athanasius Kircher, *Obeliscus pamphilius, hoc est Interpretatio nova et hucusque intentata obelisci hieroglyphici quem non ita pridem ex veteri hippodromo Antonini Caracallae,... in agonale forum transtulit... et... erexit Innocentius X..* Rome, L. Grignani, 1650.

[5] Anne Claude Philippe de Caylus, *Recueil d'Antiquités, Egyptiennes, Etrusques, Grecques et Romaines,* T.1*,* Paris, Desaint et Saillant, 1752., p.XII de l'avertissement.

3, published in 1812, seeks details on a double page ; in Volume 4, plate 72 (fig.7), published in 1817, renders the rendering of an architectural view in a more aesthetic spirit. Plate 5, in volume 5, of 1822, stands out, no doubt because it is a royal edition. With the Empire over, the King was aware of the scientific and political importance of the Egyptian expedition, both for the French and foreign public, although without much credit. If the edition is contemporary with Champollion's discoveries... they come too late for this volume. A second edition with the title *Histoire scientifique et militaire de l'Expédition française en Egypte* completed the first from 1830 to 1836. But the colours are rare...but Egyptomania was born, so that Arago's reference could be happy ! Especially since the conception of writing, even hieroglyphs, does not require colours, almost negating the colourful context of Egypt.

When Arago described the daguerreotype process in front of the Chamber of Deputies, he took up the observations of the physicist Jean-Baptiste Porta on the camera obscura. He detailed them, even quoting "with natural colours"[6]. Of course at the end of the Enlightenment and the beginning of French romanticism, every painter knew and used the camera obscura in the Italian countryside on his way to and from Rome. It was in Italy that Talbot also thought of fixing this image ... The camera lucida was itself widely used. …It is fair to note[7] that Arago discreetly added: "One wondered whether, after having obtained with the Daguerreotype the most admirable degradations of tints, one would not succeed in making it produce colours : in substituting, in a word, pictures for the kinds of aqua-tinta engravings that are now being produced ". But he preferred to insist on the accuracy of the daguerreotype.... One can assume that Arago, who had discovered the diffraction of light, could not but be interested in colour. In the same note, he adds : “This problem will be solved the day we discover one and the same substance that red rays will colour into red, yellow rays into yellow, blue rays into blue, etc. M. Niepce already pointed out the effects of this nature, in which, in my opinion, the phenomenon of coloured rings played some role. “ He only recalls Niepce for his failure...The daguerreotype can wait for colour ! One day !

Arago forgot this sentence

When he read what the painter Delaroche[8], then considered the great painter of the time, had written, Arago preferred to pass over in silence this sentence[9]: The colour is translated with such truth that one forgets its absence”. A very beautiful sentence, perhaps critical, about the daguerreotype ! Would Arago have refused this preterition ? Many historians of photography have done the same except for Cromer in 1930 and Paul-Louis Roubert[10] in 2004… For his dioramas, Daguerre[11] worked on light and transparency for the colours : without archives of his papers that disappeared in the fire of his workshop,[12] his work cannot be followed. However, he was not a chemist and it took the help of Gay-Lussac and Dumas some years later to improve his

[6] Louis-Jacques-Mandé Daguerre, *Historique et description des procédés du daguerréotype et du diorama*, *Nouvelle édition*, *Paris, Giroux*, La Rochelle, Rumeur des Ages, 1982. p 10.
[7] DAGUERRE 1982, p.27.
[8] Member of the Académie des Beaux-Arts since 1832, he is considered as the painter of the new ideas : cf Paul Delaroche, *Un peintre dans l'histoire*, Paris, RMN, 1999. p.248.
[9] Fot the text see : Steffen Siegel, 1839. *Daguerre, Talbot et la publication de la photographie. Une anthologie,* Paris, Macula, 2020. p.294.

[10] Paul-Louis Roubert, *Introduction du modèle photographique dans la critique d'art en France, 1839-1859*, Paris, 2004.
[11] Stephen C. Pinson, *Speculating Daguerre, Art and enterprise in the Work of L.J.M.Daguerre* , Chicago, The University of Chicago Press, 2012.
[12] *Journal des Artistes*, 10 mars 1839, p.157.

process. His first daguerreotypes[13], given to Arago who bequeathed them to the City of Perpignan, are now faded... He had chosen white items to capture the light. Without colours ! However, Daguerre took large, very colourful pictures for the new theatres that were dioramas[14] and panoramas, which leads us to suppose his frustration with the daguerreotype. He had sought the greatest illusions, choosing different processes to give the best to his viewers. As Stephen Pinson[15] reminds us, Daguerre had been an opera decorator. Thanks to the *Journal des artistes*[16], we know how much he worked on the illusions due to the light to restore the colours of his neorama *Abbey of Westminster*... His great paintings were so famous that everyone wanted to admire them, even the King[17]. It had become a must, the illusion of being here and there. A journey without leaving Paris ! The exhibitions created a phenomenon of expectation, as reported in the *Journal des Artistes*. Thus, a year before Arago's intervention, on 25 March 1838 the Paris diorama presented *A Sermon in the Royal Church of Santa Maria in Monreale*. Let us also note that in 1832 the *Journal des artistes*, so fond of Daguerre's novelties, published on January 15 an article by Miel : *De l'architecture polychrome chez les Grecs*[18] which is the transcript of the lecture given to the *Société libre des Beaux-Arts*. The first quotation of the colour concerns the architecture of Babylon, then the next one that of Thebes in Egypt: that is to say "the East" - very extensive at that time... The most interesting passage for us is the passage of the Byzantine art and Paestum to support Hittorff's theory. (fig. 8-10)


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M. Miel needs to describe *green* Sicily to accept the necessity of colour in Greek architecture ! He draws a parallel with the Egyptian expedition: "But when on these monumens, contemplated more closely, one could distinguish the brilliance of the most vivid and fresh colours, admiration was brought to a climax. Our artists, our scholars, our warriors, greeted the city of the Pharaohs with cries of universal enthusiasm, and the desert resounded with the transports of a whole army." What we must emphasise is that the presence of colours in architecture was easy to admit for the Eastern countries, but not for the source of civilisation, thought to be unique, the Western one with the Greeks as ancestors. At that time, not all archaeologists shared Hittorff's theory : Raoul-Rochette, then secretary of the *Académie des Beaux-Arts*, even affirmed that Greek art was free of any Egyptian influence[19]. So, Egyptian hieroglyphs, signs of writing, would have no need of colours, in an Egypt so colourful !

[13] Ville de Perpignan, Musée Hiacynthe Rigaud, n°55-1-1 à 55-1-4.
[14] Guillaume Le Gall, *La Peinture Mécanique, Le Diorama de Daguerre,* Paris, Mare et Martin Arts, 2013
[15] PINSON 2012, p.13-50, chapter 1 : The reign of speculation.
[16] *Journal des Artistes*, 23 mai 1830, p.582-584.
[17] The Sicilian Majesties, in *Journal des Artistes*, 23/05/1830, p.591, and the King of France for the Mont Blanc in *Journal des Artistes*, 20/11/ 1831, p.567.
[18] *Journal des Artistes*, 15/01/1832, p.50-55.
[19] Désiré Raoul-Rochette, *Cours d'archéologie, professé par M. Raoul-Rochette, à la Bibliothèque du Roi, tous les mardis,* Paris, Renduel, 1828.

Colour in photographic processes will have to wait for a long time to be successful and accepted, another story that we will not write today[20] .

How daguerreotypes may be coloured?

Because the daguerreotype is an *unicum*, it is not reproducible: but it was used for engravers to use as they did with drawing. Girault de Prangey made many daguerreotypes during his trip to the Orient in order to publish lithographs later. This was a widespread practice, especially as a silver plate could be reused after erasure. As Catherine Pinguet[21] writes, Girault de Prangey never mentioned that his lithographs were engraved from daguerreotypes. What is usual, "normal", is implicit. Some of these daguerreotypes have been preserved, so that one can compare the silver image and the engraving : (fig.11-13)


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The engraving plate is made clearly without colour, very scientifically. This lithograph found on the net [22], although of a different object, is translated into colours, much more attractive. Girault de Prangey has a lot of blue skies in his daguerreotypes : this is due to overexposure, which is very common in southern light. In his views in France, taken before his trip to the Orient, his daguerreotypes do not have this colour. Did he abuse overexposure to render the local colour of the South, the blue of the sky and the blue of the sea, as in Greece ? (fig.14-16)


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16

It is difficult to estimate the number of silver plates used for the edition, especially as they were usually destroyed by the printers. Are the rare exceptions the choice of the author ? The good quality of the image ? Of the good conservation, thus of the good process ? But what is certain is that there are a few technical works for colouring the daguerreotypes

[20] Cf : Nathalie Boulouch, *Le ciel est bleu*, *Une histoire de la photographie couleur*, Paris, Textuel, 2011. et les travaux italiens, ainsi que ceux de Lavédrine : https://arxiv.org/abs/2001.05250
[21] See : https://heritage.bnf.fr/bibliothequesorient/fr/Girault-de-Prangey (see on June 2022).
[22] D'autres appartiennent à la bibliothèque de l'Institut de France.

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themselves. For example, in 1852[23] Adolphe Legros explains his technique for colouring daguerreotype portraits, Chapter 16 : "Colouring Daguerreotype Prints" in four pages. The application is no more chemical than the process itself... However, the previous chapter "Of Colours and Brushes", describing the material, states : "The artist, by mixing his colours with taste and skill, can give his portraits a certain relief which they would not have in the hands of a man without taste and who would not have known how to draw all possible advantage from their union". This recourse to the notion of the artist is noteworthy. Could it be because the idea of colour could be associated with a lack of taste ? Moreover, it seems that the colouring of daguerreotypes was a more important practice in portraiture[24] and in American practice. As for Girault de Prangey, he was unrecognised throughout the 19th and 20th centuries, although he was in correspondence with Raoul-Rochette... He had to wait until the 21st century to have his work recognised as an archaeologist and photographer.

An absence of colour filled in?

The *Stratonice*[25] daguerreotype (fig.17) kept in the Musée Ingres in Montauban is most interesting : it is the intimate full-length portrait of the main character. With her profile bent over, her head resting on her hand, the young woman is in a reverie or meditation. It is a detail of Stratonice from the painting *La Maladie d'Antiochus* painted by Ingres in 1840 when he was director of the Academy of Rome.

17

18

This image has suffered from the passage of time and perhaps from the colouring processes themselves. Fingerprints and chemical alterations disturb its legibility. In any case, the pink of the dress and the skin underline the grace of the young woman. One could almost believe that this is a portrait of the model and not a Daguerrian reproduction of the painting. Is this a study for which the painter tried out these colours? Is this image based on the version in the Musée Fabre[26] (fig.18) ? Or is it a non-reversed image [27] ? Ingres composed the painting of Stratonice for which he requested the collaboration of his architect friend Hittorff[28], who proposed the framework of antique interior architecture. Ingres the great painter loved colours as well as new techniques, in the

[23] Adolphe Legros, *Daguerréotype : photographie sur plaqué, nouvelle brochure, perfectionnement, composition du chloro-bromure de chaux... moyen de colorier les épreuves*, Paris, l'auteur, 1852.

[24] François Brunet, William B. Becker, *L'héritage de Daguerre en Amérique : portraits photographiques, 1840-1900 de la collection Wm. B. Becker*, Paris, Mare & Martin, 2013.

[25] This one had been published in the exposition *Ingres et l'Antique*, in 2006. Musée de l'Arles et la Provence antiques.

[26] On the painter in Montpellier, not reversed, the dress is not rose, too.

[27] In the note of the catalogue in 2006 is precised that the image is not reversed as it was the use of daguerreotype, it was the fact only for the first.

[28] Interview with Michaël Kiene.

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heart of ancient and dynamic Rome ! Did Ingres consider the daguerreotype as a sketch ? A painted daguerreotype remains a rare piece, especially for this type of representation.

Conclusions

In relative conclusion one can say that at the time of the appearance of the daguerreotype the need for accuracy was prevalent. But also the explosion of colours coming from Pompeii and Sicily through the excavations was. Only the image was still struggling to be considered for itself to the benefit of the text : hieroglyphs were seen as a writing, Egyptian of course ! Colour photography can wait !

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https://floramusee.montpellier3m.fr/flora/servlet/PhotoManager?recordId=musee%3AMUS_PHOTO%3A9354&idocsId=ged%3AIDOCS%3A16811&resolution=HIGH

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Compound words with colour terms in Albanian

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Abstract

The aim of the present paper is to analyse adjectives with binary structure in Albanian that contain chromonyms. In these compounds colour is a "distinguishing marker" (Wyler 1992: 38), namely it assumes a "significant and classificatory function" (Agnello 2013: 13) creating pairs of adjectives with opposed figurative meaning (opposite connotations). So, the union/link of [word x] + [colour term] generates new lexemes endowed with figurative meaning (idiomatised).

Consequently, colours in pairs of opposite adjectives acquire a semiotic quality (Wyler 1992: 42). In fact, in Albanian adjectives with colour terms, such as faqezi [[faqe] + [zi]] (black-(painted) cheek / blackfaced) – faqebardhë [[faqe] + [bardhë]] (white-(painted) cheek / whitefaced), refer to persons or entities with opposite attributes: on one hand positive qualities and on the other hand negative qualities.

Dealing with questions of compositional morphology by analysing complex lexical units (Schlücker 2019), the article aims to present and discuss the following aspects: colour symbolism (Dobrovol'skij, Piirainen 2002) and linguo-cultural specificities. In addition, with regard to Albanian corpora, that are quite limited, the article gives examples of colour compounds of use in context with the objective to add and describe new attestations too.

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10. Color and Education

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When a student asks: Was ist Black auf Deutsch?

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Keywords: Second language vocabulary learning, Active colour, Black Lives Matter, LangCrit

Introduction

Simply put, this paper is about racial identities and our use of language to establish them. Yet everything begins to unravel when we probe this simplicity. My cultures, as well as others I have visited and learned about, tend to use color terminology to stratify certain sociocultural communities. We call them races. Skin tones become identity markers (Roy, 2017)—compounding the complexity of the concept of color.

Although color is physically predictable, a relationship of our visual biology and the specific, structural properties of objects in our world, it is also linguistically and socially developing. Color terms (e.g., b/Black and w/White) hold different meanings for different people, even within a single language (Piotti, 2022). As described in a recent paper of mine, both how I perceive and how I produce color comes from aggregated chance encounters with contexts, constructed across collective and personal experiences (Piotti, 2022, p. 30). My understanding of color is mine and mine alone, different day by day, an entanglement of my own biases and those accepted by some nebulous majority. I have found it challenging—nigh impossible—to translate my understanding(s) of color for others. Thus, I did not know how to answer my student when she asked, "Was ist Black29 auf Deutsch?"

Was ist Black auf Deutsch?

It was Fall 2021 and I was teaching a third-semester German language course at the Pennsylvania State University, integrating a Communicative Language Teaching approach and Social Justice Pedagogy (see Piotti et al., 2022). The course was divided into units, each contextualized within a city in the German-speaking world. On that day, when that question was asked, we were learning about Leipzig. Our textbook used photography to thematize the experience of living in East Germany and taking part in the 1989 Montagsdemonstrationen, the peaceful protests against the East German government. Hoping to foster deeper engagement with the material, I had designed a lesson to compare these demonstrations of Leipzig past to the social justice protests of Leipzig present. The older photographs were in black and white. The newer ones were about Black and White.

As the students were chatting about the similarities and differences between the depiction of these two eras, a hand rose into the air. My student's question was well-formed and grammatically correct. "Was ist Black auf Deutsch?" This could have been a simple vocabulary question—a query after a direct translation. Yet she continued, staring at the photographs of Black Lives Matter events, "Isn't it schwarz? Why isn't that on this sign? Why are they using Black in Germany too?"

Her classmates paused their labored work of producing foreign phonemes. This was a question about race, and even though I worked to align our teaching and learning with a social justice framework, we had not yet touched on racial color so visibly.

Up to that point, my own understanding of German racial color was the cumulation of confusing experiences in foreign countries and whispered discomfort behind closed doors. I am not German, Austrian, or Swiss, from Cameroon, Namibia, or Argentina. I do not have any Germanic ancestry, claim to any of the Germanic cultures, or German as a first language. I have had to learn about

[29] Since the question was presented orally, I am unable to ascertain whether my student saw this word as capitalized or lowercase. As she was looking at Black Lives Matter signs, upon which Black was capitalized, I will use capitalization here.

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German—and all that term can entail—through making assumptions while observing others and asking questions to those who have the "German" identities I do not. Yet German colleagues have winced when I try to initiate conversation about *Rassen* (trans: races), immediately correcting me with, "besser: ethnische Minderheiten" (trans: it's better to say ethnic minorities). They continue with, "Könnten wir uns mit ein anderem Thema begegnen?" (trans: Couldn't we engage ourselves with another topic?). In a similar vein, superiors at my institution have advised me not to enter into racial conversations in my German language classes, offering reasons such as "we don't like to talk about race in Germany, so just don't in German class" and "it's too complex a topic to cover with those who won't understand." All of these comments align with Kulke (2015), who described race as one of the most controversial concepts in German, as well as Rühlmann and McMongle (2019), who discussed the taboo of racial talk in the German language and connected cultures.
How could I answer: Was ist Black auf Deutsch? This was an ineffable topic, rooted in cultures and identities that were not my own. I did not have the linguistic or social resources to guide a constructive conversation. I was also keenly aware that language and society are constantly developing. I wasn't sure what was happening where right now; I did not want to outdate myself or make assumptions. To add to all this, I am wary of one-to-one translations. Black is a single term with many meanings in American English. I knew there was not a single comparable term in German. Thus, I repeat the question here: Was ist Black auf Deutsch?

Racial Color

Skin is living color—a melanin marker of a developing narrative of heritage and health and duress and discrimination (Jablonski, 2012; Piotti, 2022). It is the building block to the invention of biological differences due to race (Susan Arndt in Reucher, 2017). Although skin tone is mostly biological, linked to genes and ancestry, the racial classifications that have emerged and continue to emerge from these differences are rooted in socially constructed patterns and stereotypes (Rocktächel, 2020). Yet socially constructed categories still have significance (Crump, 2014).
As an identifiable classification for inclusion (they look like me!) and exclusion (they look different!), skin color becomes one method individuals employ to construct their identity. Many align themselves within or outside certain colored boundaries; one might be Black or White or neither of these or both of these. These categories, these concrete identities, hold very real meanings for the individuals who claim them themselves or were assigned to them by others (Crump, 2014). At least in my home country, cultural movements such as Black is Beautiful, art like James Brown's *Say it Loud—I'm Black and I'm Proud*, and recent hashtag campaigns including #BlackWomenAreDivine reclaim color categorizations to dispel racist notions and affirm cultural characteristics. Other organizations pledge racial pride through violence and discrimination against other races, for instance the neo-Nazi group White Revolution. These self-identifications are just one piece to the puzzle; there are also foreign-designations. Rocktächel (2020) described a power differential between the two, whereby the former aligns with placing oneself within a group identity and the latter with someone else doing the categorizing, putting others in boxes through partial, subjective information—another layer to this already multilayered construct.
On the one hand, racial color can materialize as fixed identities, shaping individuals' thoughts, values, and actions (Crump, 2014). Along these lines, the terms themselves (e.g., Black, White) and individuals' color memberships (e.g., being Black, being White) are rooted in historical narratives of oppression and opportunity. On the other hand, the characteristics that racial colors denote, which are enacted, ascribed, and contested, are context dependent. What it means to be Black or White fluctuates. In this way, individuals negotiate both fixed and fluid identities as they navigate their racial designations. Racial colors—regulated, rooted, restricting, contested, changing, constricting—become powerful forces in individuals' lives.
Remaining blind to the fact that individuals and institutions utilize these terms to idolize and marginalize, as well as stereotype and silence is not an option (Rocktächel, 2020). Critical Race Theory undergirds such activist efforts, challenging notions of neutrality and colorblindness through

spotlighting the historical, societal, institutional, and legal structures that shape social discourse and interaction in racially discriminatory ways (Crump, 2014; Goldoni, 2017). Critical Race theorists, at least within the American sphere, see racially leveraged injustices go unchallenged and support a critical approach to address unquestioned systems. One such system is the institution of education.

Tracing the history of Critical Race Theory in education, Dixson and Anderson (2018) found that its framework and foundation continue to be a productive mechanism to disrupt education policy and practices that construct racial inequity and perpetuate normative whiteness. Through a Critical Race Theory in education, we might reject dominant narratives (about the inferiority of people based on skin color) and examine historical linkages between educational inequity and racial oppression, whereby engaging in intersectional analyses of identity markers and working towards meaningful outcomes "redress[es]" racial equity (p. 121). Qin (2020) adds to this body of literature, noting how social norms can be implicitly constructed in American English-as-a-Second-Language courses. In short: "Language curricula powerfully constitute learners' subjectivities in self-designations" (p. 856). And in her work concerning foreign-designations with English language learners, Roy (2017) stated how important it was to convey to students that labeling people (as Black, White, Brown etc.) is "neither neutral nor benign, but can lead to a process of internationalization of dominant or reductionist beliefs" (p. 543).

Linguistic Color

We, as humans, employ words to codify characterizations and groupings. This is a fancy way to say: We label. We use language to frame race and racial distinctions. Some might say, "we are Black" or "you are White." Some claim they are Brown and call others Red. As Wollrad (2014) wrote, "Es gibt keinen Rassisums ohne Sprache" (trans: there is no racism without language, p. 11). Along these lines, language helps us navigate and keep track of our identities. It can provide us with the tools to express what we are and what we are not.

Language, historically, was thought of a structured and bounded system of symbols; more recently, however, some describe it as socially constituted, fluid, semiotic network, rooted in real life practices—what people do in the language, how they negotiate constantly shifting notions, and why they produce what they produce and interpret what they interpret (Von Esch et al., 2020; Crump, 2014). I expand Crump's (2014) understanding of racial identities to language: Languages are fluctuating, social constructions as well as fixed entities with social force. At times, shifting identities might prompt language development (e.g., non-binary personal pronouns, like *they,* in American English). At other times, developing language might open the door for new identities (e.g., adopting *queer,* a term formerly associated with unconventional or questionable, as a positive self-designation by those who felt that LGBTQ did not quite fit).[30]

How we talk about ourselves and others is complicated and controversial, as we see by myriad rebukes of "political correctness" in public media and private circles alike. I have witnessed this in my own country. For example, as a young child, I loved the character Peter Pan. My family had the Disney film adaption of the story and I could sing every word to "What made the Red Man red?." Knowing I loved this narrative, someone gifted me the book *Peter and the Starcatchers* (Barry & Pearson, 2004), a prequel to the classic tale and also published by Disney. There was Tinkerbell and Captain Hook and the native tribe called themselves the Mollusks. I remember asking a parent why they were Red Men in the film and Mollusks in the book. I learned that Red Man was no longer politically correct because it was racist, describing an ethnic group by an erroneous appellation for their skin tone. "Was Disney racist back then?" I asked. That question went unanswered. "My skin is not white, and black is not really a skin tone either," I added. "Are Black and White not politically correct?" That one also went unanswered.

[30] To note: The term LGBTQAI+ is now used as a more flexible alternative, whereby the + is an open category for other identities.

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It was years later that I watched the 1953 Disney film in German and heard the song in my foreign language, *Warum ist die Rothaut rot?* (trans: Why is the red-skin red?). Yet, for me, Red Man (or Redskin) and Rothaut are not direct translations because red and rot are different. In my worldview, red ties to political ire (e.g., the Republican party) and savage persecution (e.g., colonial pogrom of Native Americans). Red is MAGA hats and the Redskins logo. Red is anger, hate, distrust, and violence. The concept of Red Man is saturated with these connotations—Rothaut is something different for me and it was something different for Germans. This does not mean that I am fine with the term "Rothaut"—it just means that the conversation surround it's use is different.
I include this long anecdote to demonstrate the intersection of and interaction between language and race (especially racial color), to home in on the complexity of racial designations (just within one language), and to frame the problem at hand (how to translate racial classifications).

LangCrit
Race, language, identity, belonging—the intersection of these concepts, LangCrit, materializes as an offshoot to Critical Race Theory (Crump, 2014). As described by Crump (2014), a critical theory of language and race acknowledges fixity, as well as historical and culturally relevant hierarchies and boundaries, but challenges assumptions by accounting for the possibilities of being and becoming through local language practices and individuals' narratives. Von Esch et al. (2020) added that LangCrit becomes a conceptual lens to dispel notions of colorblindness, which supports de-emphasizing or ignoring racial membership, allowing racial injustices to continue (Whitley et al., 2022); of color evasiveness, which denies racial difference by emphasizing sameness, justifying discriminatory racial status quo (Neville et al., 2013); and of colorism and color-based racism, which is apparent in products such as skin creams (see: Kahn & Kahn, 2022) and digital face-tracking software (see: Fisher, 2010), respectively.
When race is recognized as a part of language, racialized ideologies, racialized histories, and racialized identities become part of language teaching and learning (von Esch et al., 2020). Yet, as already discussed, race-based constructs, racial-based conditions, and race-based colors are context dependent and cannot be translated one to one (Rocktächel, 2020). Thus, LangCrit becomes a productive framework for language teaching and learning spaces, both for instructors (as they teach the entanglement of race, ethnicity, and nationality; conventionally used and politically correct terminology; and developing constructs and fixed stereotypes) and students (as they grapple with new concepts, explore new perspectives, develop new discourses, and construct new identities—all while examining and problematizing previously held worldviews).
As I understand it, LangCrit moves beyond the use of images and texts from diverse speakers, situations, and locations; it encourages discussion on and problematization of the presence and the absence of diversity in our spheres. LangCrit disrupts the notion that providing racial vocabulary reinforces differences and otherness; it embraces the process of seeking out racial intersectionality and identity in our learning spaces. LangCrit defends a proactive, rather than reductive or suppressive, approach to discussing race in a language classroom.
As I dig into the nuances of answering "Was ist Black auf Deutsch," I employ a LangCrit framework to work through grammatic, semantic, pragmatic, and locative variation of racial designations in German discourses (and American English).

Grammatic: considering schwarz
A distinction is being made here between Black and black. In short: "Black with a capital B refers to people of the African diaspora. Lowercase black is simply a color" (Tharps, 2014). This grammatical move draws from a rich history of re-naming and reclaiming language for Black Americans. For instance, at some point in the 1920s, W.E.B. Dubois fought for the use of capital-N Negro (although he himself used capital-B Black), writing to the editor for the Encyclopedia Britannica: "the use of the small letter for the name of twelve million Americans and two hundred million human beings is a personal insult" (as quoted by Burke, 2020, p.x).

More recently Nguyễn and Pendleton (2020) made the case that capitalizing Black necessitates capitalizing White as well. Without doing so, White is "neutral" and "the standard." By doing so, White is a proper noun, ascribing accountability for White individuals' and White institutions' involvement in racism (n.p.). Yet these authors reckon with the fact that White supremacists have also capitalized the W in efforts to establish (often violent) power over others. Nguyễn and Pendleton ultimately condemn the individuals who capitalize for the sake of dominance over other communities, and reclaim capitalization as a method to prompt deep thinking about racial terms, and the individuals and the communities they name.
A similar conversation is also taking place in several German-speaking communities—though I feel it is complexified. In standard German, most nouns are capitalized. This means, that the sentence: Im Vergleich zu den Schwarzen haben die Weiße mehr politische Macht. (trans: In comparison to Blacks, Whites have more political power) would already contain capitalized letters for the racial designations Weiß(e) and Schwarz(en). Yet in recent years, mainstream news outlets are printing color-based adjectives that describe humans, which would not be traditionally capitalized, with capital letters. One example from *Die Zeit* is: Es beschreibt Schwarze Menschen, die sich selbst unterordnen… (trans: It describes Black people, who are subordinating themselves…) (Wengert, 2020). If I draw parallels between capitalization practices in these two languages, I might answer my student with, "Black hier ist Schwarz, aber nicht schwarz."

Semantic: considering *Schwarz*
As I contemplate the grammatical distinction made by the local media, I cannot help but bring in the semantics I learned as a foreigner. I was sixteen when I first visited a German-speaking place and used busses and trains for public transport. I was living with a lovely, law-abiding German family, who emphasized the importance of not only purchasing a ticket but validating it at the beginning of my ride. I was to board, find the nearest validation machine, and stick my ticket into it—otherwise, I would be a "Schwarzfahrer(in)." Being a "black rider" would be a horrible thing; it meant I was a poor person, a cheat, or a trickster.
In the decade since then, I have come to notice how other compound words with schwarz seem pejorative. For instance, although "Malerie" is painting, art, professional work, "Schwarzmalerie" is pessimism and "Schwarz sehen" (trans: to see black) is to be pessimistic. While "Arbeit" is job or occupation, "Schwarzarbeit" is illegal employment. And if one were to learn about an illegal worker, that individual might make that worker black (anschwärzen, trans: denounce them). In response, the worker might become black-angry (trans: sich schwarzärgern). Even if I were to use a capitalized Schwarz, the plethora of negative connotations curbs my use of the seven-lettered term. Although I might not be an expert in political correctness as a foreigner, all this feels disrespectful. I distance myself from Schwarz as well.

Pragmatic: considering *ethnische Minderheit* and *Migrationshintergrund*
In my search for politically correct terminology, I asked German friends and colleagues. They also feel hesitancy in using S/schwarz and said they opt for ethnische Minderheit (trans: ethnic minority) or Migrationshintergrund (trans: migrations background). These terms are used in public policy documents as well, they told me. Although politically correct pragmatics might compel native speakers to use such phrases, I feel I am unbridled from such practices as an L2 speaker. In my parsing, these phrases are discriminatory and non-inclusive in their common use.

1) ethnische Minderheit: I have lived and worked in Germany and Austria, but I was never classified as an ethnische Minderheit, despite the fact that I technically was. Concerning my ethnicity, as an Italian-American, I was in the minority. Concerning my skin color, as fair skinned, I was not. Despite its use of ethnisch, this term seems to distinguish people based on appearance rather than ethnicity, conflating race and ethnicity, and grouping individuals by color (as White or not-White), rather than by ethnicity.

2) Migrationshintergrund: Similar to ethnische Minderheit, Migrationshintergrund also seems to delineate those living in German spaces based on appearance. My White American friends who move to Germany, they do not have a Migrationshintergrund. My Black friends do. I have also met darker skinned individuals who have resided in the German speaking world for decades, much longer than their neighbors who immigrated from Poland in the 1990s. The former still have a Migrationshintergrund and the latter do not.

In thinking about teaching these two terms, I am daunted by teaching language that I feel is discriminatory (in that it otherizes dark skinned individuals in roundabout ways), even if it is what is used by the speakers. Do I teach language that is used or language that is socially just? What I want is a term that can do both. I continue my search for Black auf Deutsch.

Locative: considering *Afro-Deutsch*

It was several years after the Mollusk-Red Man discussion, around the time that Barack Obama was running for President of the United States, that I was told to use the term African American in place of black (I hadn't learned about the capitalization yet). Just as I had switched from Red Man to Native American, I should make a switch to African American. In recent reading on this topic, I learned that the appellation was heavily campaigned for in the 1980s, as Black Americans emphasized their collective, historical connection to Africa. This was portrayed as comforting—providing an ancestral story for those without one—for as Dilday (2008) described it, "one of slavery's many unhappy legacies is that most black Americans don't know particulars about their origins" (n.p.).

Yet whoever asked me to use African American, was naïve to the fact that the b/Black community felt the term to be "imprecise" (Izadi, 2020, n.p.). There were individuals in this community who felt that the term was too inclusive. They asked questions like: Do you have to be an American citizen to be an African American? What happens if your more recent ancestors came from other places, like the Dominican Republic, and you feel more kin with them than with Africans? Then there were others who felt that the term was too exclusive, as it "ignor[ed] the continuum of experience that transcends borders and individual genealogies and unites black people all over the world" (Dilday, 2008, n.p.). In 2008, Dilday ended a piece in the New York Times with: "It's time to retire the term African-American and go back to black" (n.p.). I feel we have.

And what about Afro-Deutsch? Although the term has fallen out of favor (as conversations similar to those taking place in America, take place in the German-speaking world), it's often the one that I use—applying lessons from childhood to this next culture and language.

Before concluding, I feel the need to add something else. The student who asked for Black auf Deutsch was a Black woman from Pennsylvania. Though I do not know for sure, her question might also been one of self-identification. As a Black American, Afro-Deutsch was not going to work. She might not associate with any African ancestry and she was not Deutsch.

Perspective: considering *Black*

When my student asked "Was ist Black auf Deutsch?," I wanted to respond but was not sure with what. With schwarz or Schwarz or Afro-Deutsch? With Ethnische Minderheit or Migrationshintergrund? All of these seemed problematic. None of these were what my students understood as Black. Yet whatever phrase I might have provided to my classroom full of students, they would have taken everything they understood as b/Black and mapped these notions onto this new term.

Working under a social justice pedagogical framework and believing in LangCrit, it would be my responsibility to guide students towards problematizing racial histories and cultural contexts we had not lived. I gave it my best effort and said, "That's a complex question. When we learned the colors, like rot, gelb, blau, we called black, schwarz. But Black is more than that, isn't it?"

I then offered my best guess. In that moment, in Leipzig, it was the word Black on the Black Lives Matter sign. Thus, Black was Black auf Deutsch—at that moment. Perhaps the sign-holders were

Germans, showing support for Black Americans: Black Americans identify as Black, so these Germans used the term to acknowledge that. Perhaps they were Germans who were discontented with their language's lack of an appropriate word (in my opinion) and penned Black as a substitute. Perhaps they were not even Germans and opted to use terminology they knew worked for the context (i.e., Black) in a foreign city. In that moment, did it matter what Black auf standard Deutsch was? There. In Leipzig. In Summer 2021. At a Black Lives Matter protest. It was Black. In other parts of the German-speaking diaspora, during another time, in another context, Black might materialize as myriad other terms.

When a student asks: Was ist Black auf Deutsch?

Two questions drive this paper. I have worked through the first: Was ist Black auf Deutsch? And I have come to the conclusion that there might not be a single answer. That B/black is untranslatable in German. Just last week I learned that maximal pigmentiert (trans: maximally pigmented) was used in eastern Germany in the early 2010s. Some German friends also told me that farbig (trans: colored) had trended several years ago, though was considered racist by those who now opted for BIPOC (Black, Indigenous, and People of Color). A colleague advised me to follow #wasihrnichtseht (trans: #what ya'll don't see) on Instagram. I now do, learning about Germans' lived experiences of discrimination and the words, phrases, and actions that make them feel uncomfortable, disrespected, or in danger. As more stories are posted, the language will change—I am sure. Languages and identities shift.

With this unsatisfactory "answer" to the first question, I now want to attend to the second: How might a teaching moment arise, when a student asks: Was ist Black auf Deutsch? In my opinion, racial labels, especially those with color-tinted roots, must be explored through historic, culturally-specific lenses. This is daunting, some claim unfeasible, in language classrooms. Viewing the Black Lives Matter in Leipzig scene through a context-, background-, perspective-dependent lens, multiple narratives arose. We were not certain (it was not our place to be certain) which narrative might be real, but the process of exploration and reflection allowed us to consider several ontologies. As I see it, it was the critically thinking and perspective taking that answered the question. To me, it is less important to provide my student with a laconic translation and more to begin the conversation that I have laid out here. I already said this was formidable: To resist certainty and open the door for partiality and perspective-taking often is. But teaching language is controversial, challenging, and complex. That's part of the job and part of what makes it wonderful. Truthfully, I find it even more unsettling to be responsible for providing my students with accurate translations for untranslatable concepts.

This process takes honesty and humility (I admit to my students, "I do not have a perfect answer"); it takes self-reflection, a growth mindset, and a decentering of teaching and learning (I encourage with, "let us all draw from what we do know and share, yet also think critically about where those understandings came from and what they mean for others"). The process of asking a good question might entail asking more questions before finding at least some answer that makes sense for that context.

Thus, I leave the reader with other questions I have asked. Some of them have been inspired by the works of Sawyer and Meadows (2012), Roy (2017), and von Esch et al., (2020) and others I have been tossing around for years. Be in touch if you ever want to work through them—together.

- When we provide translations for culturally contingent vocabulary, how do we guide students towards making comparisons that are both accurate and just? How do we teach connotations without stereotyping or providing narratives that are not our own?
- How might the discourses of the cultures we teach be prioritizing certain voices in those cultures? Whose voices are included in "standard" Language X? What happens when discourses are incompatible—when the majority uses language in one way and minorities in different ways?

- Do we take a functional (actual) or a critical (socially just) approach to language teaching? Do we teach the language that is used or the politically correct or socially respectful language that could be used?
- How do we help students navigate the identities they could, should, or should not use in the language? What happens when our students have identities that are not (yet?) present in the language? Is it more important to have an identity in the language classroom, using language they normally use to identify, or an identity that makes sense to those who live in the cultures and speak the language(s) being learned?
- How do we grapple with our own subjectivity while answering and acting on our answers to these questions?

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A New Paradigm for the Definition and Universe of Static Colors and Dynamic Colors

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Abstract

This article presents a new paradigm, for the definition and universe of *Static Colors* and *Dynamic Colors*. As the central issue, this new paradigm is presented, from the perspective of the study on the colors and natural pigments of the Serras do Socorro and Archeira, and its use by the Association Live With Earth - ECO CAMPUS, Torres Vedras.

The author considers the current definition in force to be small and incomplete, which tells us that "*static colors* are cold colors associated with terrestrial poles, and *dynamic colors* are warm colors associated with equatorial regions." On the contrary, it defends and proposes a new paradigm and definition, in which "*static colors* are the colors that come from the human being, and *dynamic colors* are the colors that come from nature." Is a new way of seeing colors, and understanding from a wider overview, how the colors co-exist and how they communicate.

This new paradigm essentially contemplates one of the triangulations resulting from the *Advanced Methodology in Design of Divergence-Convergence*, which groups five works by different authors, transposing for each triangulation a "project track"/keyword, in a very concrete idea: The Order of Group as the pigment and the isolated color and the Order of Symmetry as the junction of pigments and the colors in metamorphoses (Gevin Giorbran, Everything Is Forever); The Rainbow and Halos as *dynamic colors*, the reproduction of colors of photography, film and television as *static colors* (Luis Bernardo, Histórias da Luz e das Cores); The causes that originate the colors of the soils and the understanding of color in Geology (Caracterização e Constituição do Solo, Joaquim Costa); The rationalization of colors and the creation of definitions and color codes in various fields, as part of the birth of static colors (Johann W. Goethe, Doutrina das Cores); The holistic view of the world and education for sustainability through natural pigments (Gaia Education, Education for Eco-Village Design).

In order to understand this concepts, the author explains us in this article the difference between *static colors* and *dynamic colors*, and how this can be compared for example with music, which is a human interpretation of the sounds of nature, choosing 7 main notes, between an almost infinite number of sounds. The same happens with the *static colors*, which are the human interpretations of colors and creations through colors. Colors that come from nature, from the source, the *dynamic colors*. With the objective of adding value and knowledge, about colors and natural pigments in the universe and discipline of Design, this investigation starts with this proposed new paradigm and definition, is developed by a set of recipes and eco-products, generated from the results of various practical experiences and prototypes, and culminates in a new mindset and sustainable model of social innovation, by local action for global change: *Serlumen*.

Keywords: Static Colors, Dynamic Colors, Colors in Humans, Colors in Nature, Communication, Design

1- What is Light?

Everything about color starts from light, so before approaching colors and our human understandings about them, we need to understand their source of existence. Light, or also called “visible spectrum” is one of the frequencies, and type of electromagnetic radiation, with it's specific

wavelenght and photon energy, from the **electromagnetic spectrum**. Is the part of the spectrum which can be perceived by human beings, by the sense of vision. "*The electromagnetic spectrum covers electromagnetic waves with frequencies ranging from below one hertz to above 1025 heartz, corresponding to wavelenghts from thousands of kilometers down to a fraction of the size of an atomic nucleus. (...) beginning at the low frequency (long wavelenght) end of the spectrum these are: radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays at the high-frequency (short wavelenght) end."* (Wikipédia)
Light has been intensively studied from the beginning of the 17th century and has lead to many innovations. Isaac Newton was the first to use the term *spectrum* for the range of colours that white light could be split into with a prism. In 1666, Newton could prove that colours were intrinsic to light and could be recombined into white light. In this way, was now clear that colors have their source in light, and that with our vision we could perceive colors in environments where light exist and reveals them. Much more about light can be found in Optics : "*Optics is the branch of physics that studies the behaviour and properties of light, including its interactions with matter and the construction of instruments that use or detect it."* (Wikipédia). One of the main contributions for borning Optics, specifically "*physical optics*" was the book "Opticks" (Newton, I. 1704) which analyzes the fundamental nature of light by means of the refraction of light with prisms and lenses, the diffraction of light by closely spaced sheets or glass, and the behaviour of color mixtures with spectral lights or pigment powders. Optical science is one of the most important areas that was discovered and used as a veichle for the evolution of humankind in the last century. It is used in many different disciplines (medicine, physics, arts, design, engineering, etc) and many practical applications can also be found in a variety of technologies and everyday objects, including mirrors, lenses, telescopes, microscopes, lasers, and fibre optics.

2- What is Color?
One of the main objectives of the presented theory in this article, is to **step out of the Anthropocene** sphere of thought, behaviour and action. To achieve this possibility, one of the starting points is to understand that we, as humans, are not alone in the Planet Earth. One of the ways to understand this idea, and transposing it to the fields of light and colors, is to observe and study how other species, **rather than humans, perceive light, colors and the whole electromagnetic spectrum with their senses**. This will lead our thoughts to the complexity of life, and to position ourselves **"humans as part of Nature"**.

"Many species can see light within frequencies outside the human "visible spectrum". For example, bees and many other insects can detect ultraviolet light, which helps them find nectar in flowers. Birds, too, can see into the ultraviolet (300–400 nm), and some have sex-dependent markings on their plumage that are visible only in the ultraviolet range." (Wikipédia)

Other important idea to reinforce, is that humans have developed their own belief systems, including the color systems. Let's take a look for example in Color Theory **:** *a body of practical guidance to color mixing and the visual effects of a specific color combination. Color terminology based on the color wheel and its geometry separates colors into primary color, secondary color, and tertiary color.* Now we can observe "color harmony" : *In color theory, color harmony refers to the property that certain aesthetically pleasing color combinations have. These combinations create pleasing contrasts and consonances that are said to be harmonious. These combinations can be of complementary colors, split-complementary colors, color triads, or analogous colors.* (Wikipédia)
Also the distinction between color produced by light (RGB) and color printing (CMYK) is important to understand, as a foundation for the development and communication of *static colors***.**
In my perspective, color theory, color harmony, and any line of thought concerning colours, are the ways in which humankind has **created and defined it's own perceptions and understandings** about the colors existing in nature. The observation of the complementary colors, it is another example of the creation of *static colors*, by humans. In this case, with full saturated "hues", and

combining them to do the studies of comparing and creating contrasts between colors. This is impressive, in the way that allow us humans, to understand the possibilities and limits between colors, in a way that wouldn't be possible through the observation of the complementary colors in the *dynamic colors* of nature. Because the *static colors* generated by humans, **can be modified and manipulated** in order to be perceived with higher intensity, and so, the contrasts between them are more impactfull. The distinction between warm and cool colors is also important for this research.

In **Astrological Connections**, with the planets, the four seasons, the numerology, the signs from zodiac, there is a connection with nature, through colors, and mostly trying to study and to understand the colors of nature and how they relate to human beings. In **Symbolism**, in my perception, humans started to develop the mechanisms of thought, and synapsis in the brain, for the development and materialization of the *static colors*, giving symbolic meanings to colors. For example the basic associations with white as light and divine, and black as dark or evil. With this assumptions, humankind started to project their own ideas and interpretations, developing the imaginary, the collective subconscient, through the psyche, arts and language. Rudolf Steiner and the **Antroposophical System,** brings another interpretation about colors, in this case, the green as the main color, from nature. Through History, genious and unique persons has discovered more about themselves, and their own interpretations of the universe of *static colors*, studying and designing color systems, with the most diversity of approaches, creativity of expression, developing theories about colors, and our human perceptions and understandings about them. From Pythagoras, Aristotle and Plato, and the philosophies around the rainbow and light, to Isaac Newton who separate daylight with a prism, counting seven individual colours and revolutionizing science, promoting human evolution. Johann Wolfgang von Goethe, which gives us the perception of the emotions caused by colors, connected with the senses and sensibility of the human being... James Maxwell, introduces the origin of colorimetry. Albert Munsell, and many other modern ones such as DIN System, ISCC-NBS-System, OSA-System, NCS-System, Coloroid-System, CIE-L*A*B*-System, ACC-System, HLS-System, RGB System, CMN System, are in my opinion, examples of *static colors*, and all of them form an enormous contribution for the understanding, usage and communication about colors.

3- What is Static and Dynamic?

The science of Classical Mechanics *“is a physical theory describing the motion of macroscopic objects, from projectiles to parts of machinery, and astronomical objects, such as spacecraft, planets, stars, and galaxies. For objects governed by classical mechanics, if the present state is known, it is possible to predict how it will move in the future (determinism), and how it has moved in the past (reversibility).*

It considers Statics as the branch of classical mechanics that is concerned with the analysis of (force and torque, or "moment") acting on physical systems that do not experience an acceleration (a=0), but rather, are in static equilibrium with their environment. It considers Dynamics the branch of classical mechanics that is concerned with the study of forces and their effects on motion. Isaac Newton was the first to formulate the fundamental physical laws that govern dynamics...” (Wikipédia)

4- Which are the current definitions of Static and Dynamic Colors?

Currently, acording to my research, the current definitions for static colors and dynamic colors are described before in this article, and is related to the color temperature, specifically the warm and cold colors. In definition, dynamic are associated to warm colors, and static to cold colors. Everything which this perspective represents, in terms of color frequencies, symbolism, and in general, are for me very reductionist, comparing to the potential of understanding and level of consciouseness of the theory and paradigm presented in this article. For me, this is an example of stepping from a system of colors, in this case, an example of *static colors* created by humans, to the new definition, from a position outside the anthropocene, and with a bigger range and overview of vision according to colors, and also spiritual connection telling the soul that humans have their own creations, and these creations are part of nature, and never isolated or forgotten. Rather than to be, just the human perceptions around colors, it should also be, the human perceptions around colors, inside the universe of colors of nature. In the current and official definition, the qualities associated to each static or dynamic colors, are not in coherence with the current definitions of physics and other brenches of science: cold colors have a shorter vibration wavelenght and a **higher frequency** level, usually associated with speed or movement, which reveals a curious fact that goes against the assumption that cold colors are considered static, with little movement or vibration, soft and calm. In the opposite, warm colors have a longer vibration wavelenght and a **lower frequency**, usually associated with slowness and low intensity, which also reveals that it is against the fact that warm colors are considered dynamic, fluid, very busy and vibrant. At geophysics, static colors are associated with the north and south poles of our planet, and also with cold regions, and dynamic colors are associated with equatorial regions and hot zones, not only because of existing temperature, vibration and life, but also because light affects different parts of the planet in different ways, due to the angles of solar incidence and the shape and rotation of the Earth, producing more or less saturation.

5- A New Paradigm for the Definition and Universe of Static Colors and Dynamic Colors.

I observe this autumn landscape. Green robes, brown robes, ranging from more or less reddish, brownish, yellowish and greenish tones, and some even violet tones. These shades of the forest are communicating, more precisely the state of maturation and the state of decomposition of the leaves of each of these trees, revealing more to me about each part of the forest. I also see a village, mostly white, and also orange, from the roofs that indicate to me that they are ceramic tile, some gray, which leave me in doubt, some darker, of which I can not identify which material they represent. I see the ground, green of the vegetation and brown of the earth, some parts with clayey red tones, or orange, in other parts I notice some shades of darker green that show me that there are shadows and hedges, other parts to dark grays and other gray tones that show me terraces, and the sky, blue, hiding behind the enormous darkness that exists in the Universe.
These are the ways colors communicate. There is a big difference between the colors of the village and the colors of the forest. To this difference I call static (or humanized) colors and dynamic (or natural) colors. Rui Pessoa Vaz F. Vasques

In order to idenfity if a color is static or dynamic, in the presented new theory, in addition to the main color change factor, **light**, is also added the **time** factor, and the **erosion** factor, with the objective of making easier to conclude for each color observed, in which main cathegory or group it belongs, of **natural creation** or **human creation**. These are the three factors (**light, time** and **erosion**) important to take into account when looking at the main sources of influence that can change *static colors* and *dynamic colors*. In this way I present a new look at these concepts of *static colors*, *dynamic colors* and everything that surrounds them, bringing more about the perception of time, and other factors mentioned, as well, and mainly, a free mindset and outsider of anthropocene, able to perceive and work with the universe of colors in a new way. Hermann von Helmholtz, tells us that "the eye cannot separate colors using vision, but the ears can separate and distinguish different sounds, and also the taste can feel different tastes". At this point, is interesting to refeer the importance of this reflexion to the understanding that: **the eye see the natural colors merged together, the *dynamic colors* from nature, but also can perceive the difference between this colors, when sees the *static colors*, separated in distinguished colors by human beings**. There are phenomena in color that happen more rapidly than others, in a faster or slower rythms, such as the rainbow, autumn leaves, a rotting food, or a wound that heals, for example. Different materials have different times of decomposition or degradation. These events are of utmost importance so they cannot be ignored in the sense of understanding colors, they are everyday phenomena that can save or change a life. Between the colors of the rainbow - *dynamic colors,* that can appear for a few seconds, and the colors that we can consider that will always exist, as long as there exists humans - *static colors*, who know their definitions and their meanings.

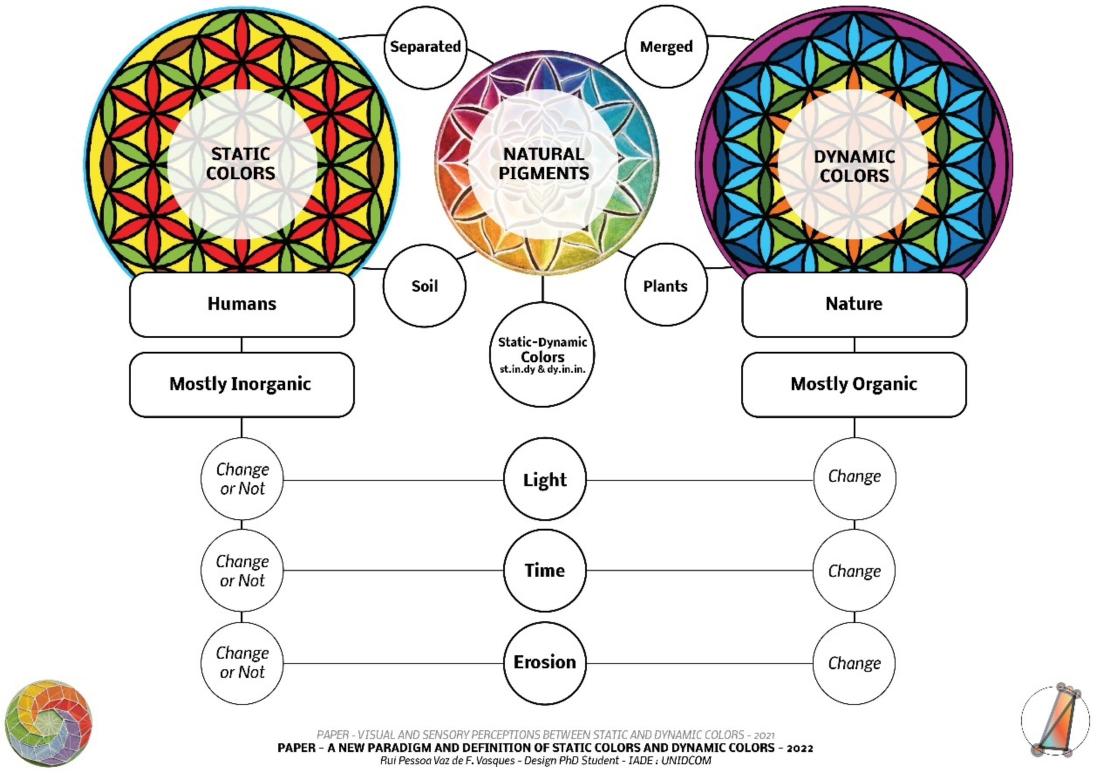

Fig. 1 – STATIC & DYNAMIC COLORS DIAGRAM, VASQUES R. 2022

It is important to introduce in this thesis, the history of color and sciences, the discoveries, in photography, in cinema, and where *static colors* touches. Theories, technologies of color reproductions created by humans, such as screens, or forms of color reproductions in color codes and catalogs (PANTONE, VYNIL, CMYK, RGB, RAL, etc...) and with the aim of defining, identifying and categorizing, resulting in *static colors*. It is very important to realize at this level that the digital world and the virtual world are human worlds, so all these worlds are made with matrices and color codes, and color bases, which are settled and start from *static colors*. While the natural and real world out here, even though the *static colors* that the human being has produced, catalogued and painted, is a dynamic world, because in the long run, even some human *static colors*, physical ones, will be altered by erosion and time, to another temporal scale. Virtual ones, and those of the imaginary, can survive alongwith the survival of human beings, particularly people who preserve and cultivate this knowledge. This is one of the reasons, that is important to notice that *static colors*, are also human habilities for manipulating the colors existing in nature, the *dynamic colors*, in a limitless way. That is why they are per definition, **transformed or not**, affected or not, by the three main factors of the theory: **Light, Erosion, Time**. On the other hand, the *dynamic colors*, are **always transformed** by these factors.
Very interesting points of convergence arise here between static colors and dynamic colors, which give "cloth for sleeves" for new theories, new study fractals, new universes of knowledge. The fact that *static colors* can also be “dynamic”, such as: if on a screen we have an image of various colors that are static by their origin, but then change visually, i.e. a movie, we can consider that they are ***static colors in dynamism***. The other example is when we have *dynamic colors* that are in static states, or in inertia, according to human time perception, for example, the mineral pigments of this research. These are ***dynamic colors in inertia.*** By applying both concepts described previously, we can better understand the considered meanings of **static – human** and **dynamic – nature,** where static represents a group order, relating to humans, and dynamic represents the symmetry order,

relating to the universe. A static color is a result from a human intention, and a dynamic color is a result of natural creation.
The explained new theory ***Serlumen*** is allowed to expand itself much more, when we observe colors from the lens of defining the groups and the symmetries existing. This means that we can find many different orders of group, orders of symmetry, and also combinations between them, in each one and in both *static colors* and *dynamic colors* concepts.

The Order of Group and The Order of Symmetry

The **Order of Group** is present in everything that is clustered by similarity, or by compatible configuration, such as different categories of objects, species, materials, chemical compounds, thoughts, and everything that can be divided as a form of organization. There may be groups within other groups, as we observed in fractal systems, for example, where shapes are repeated in different patterns that have a similar configuration, and on an infinite scale from the microscopic (micro) world to the intergalactic universe (macro). Observing the planet Earth, we can see that the human being has categorized the same at the spatial level, in different groups and scales, from the creation of continents, to countries, regions, cities, neighborhoods, condominiums, dwellings, and divisions of dwellings. In each of these group systems, there are many others that compose them internally, and also many others that are directly interconnected and synergistically in the way they interact for the perfect functioning of the whole, of the complete organism. This order is mainly connected to the *static colors*.
The **Order of Symmetry**, on the other hand, is when there is a pattern composed of at least two different groups, which repeat in an interleaved way. We can observe this order for example on roofs composed of interleaved tiles, or on avenues composed of different facades of buildings, or on a Portuguese sidewalk. Looking under the microscope, numerous materials are composed of this type of order, such as different types of skin, fabrics or leaves. Bee hives have a symmetry configuration, where combs interconnect in an efficient and intelligent pattern, for the desired functions of storing honey, reproducing larvae, and maximizing the number of holes for the smallest space and material required. This order is mainly connected with the *dynamic colors*.
It is also important to observe and understand that these two types of order interconnect in numerous situations, creating other levels of complexity in new configurations, such as spiral form, and in a dance between group and symmetry. These orders also vary depending on their frequency, i.e. the density and quantity of times they are repeated, or said otherwise, by the size of their units and times when they are repeated in relation to the whole of their whole. Low voltage orders, more organic and undefined, are usually present in the natural world, and high voltage orders, more formatted and defined, are mostly human-created. In the book "Everything is Forever", from Gevin Giorbran (2007) tells us of concrete examples related to colors, where **one color represents a group, and when added to another color, the two groups merge into a symmetry, generating a new color**. For example, by combining yellow pigments with red pigments, it will generate the perception of the orange color, because at the microscopic level, pigments of different colors generate and become a new order (from group to symmetry) giving us the notion of a new color resulting from this magical phenomenon.

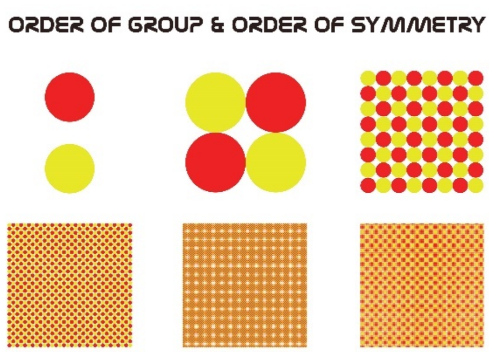

FIG 2 – Order of Group and Order of Symmetry in colors (GEVIN GIORBRAN)

Colors in Nature: *Dynamic Colors*

Dynamic colors are the source, and the basis of static colors, and are the colors that exist by themselves, and that change mostly in short time spaces, but that can also sometimes change in long spaces of time.

They are **always influenced** by **light**, **time** and **erosion,** according to the human perception, but they also can be considered (in another study) to change or not, if we observe the morphic fields (Sheldrake. R. 1981) , as an invisible memory behind colors, and the electromagnetic spectrum. Most dynamic colors come from organic or living sources, and communicate the processes and phenomena that happen mainly in nature. Examples of these processes and phenomena are the depths, dimensions, opacities, densities, toxicity levels, whether a food is edible or not, states of maturation of food, states of decomposition of objects, the existence of bacteriological processes, processes related to fungi, in the leaves of plants are reported different aspects, stains, colors, patterns, which communicate to us various information about their health and balance. Potentially poisonous animals, among other countless information that are communicated to us. This is the most basic, and primitive form of existence and communication between nature itself, including with the human being. These are the *dynamic colors*, they are the basis which form all colors.

Colors in Humans: *Static Colors*

Static colors are produced and/or catalogued by humans. They are colors that can **change or not** with **light**, **time** and **erosion**. These colors are cataloged by the humans, that is, it is as if it were the music of colors, where in similarity to the 7 musical notes, which were created from an almost infinite number of sounds of nature, also 7 colors of the rainbow were observed, analyzed and cataloged as the main colors, within the spectrum of light, and that are the summary of an almost infinite amount of different colors existing in nature. Interestingly, each musical note is associated with a color, and also associated with certain frequencies, and also associated with the 7 chakras of the human body, which are energetic points distributed along the spine and to the top of the head. This is the result of the fact that the human being has used mathematical, rational and organizational thinking to categorize colors, and in this way in my view, making them static. It is as if it were the creation of a language or a code, which makes them more perceptible among humans, easy to read, understand and communicate. Static colors come mostly from inorganic or unlive sources, and communicate the processes and phenomena that occur mainly in human nature.

6- The Natural Pigments as the Bridge Between Static Colors and Dynamic Colors

When we remove pigments from nature, and we use these pigments for the production of human colors, is the great passage and transformation, the epicenter of a study that recalls history and the history of art, and uses the transdisciplinar methodology capable to cross and merge different disciplines and perspectives. Today, in the 21st century, through Design Research, we are solving this topic: the notion of what are the *static colors* and what are the *dynamic colors* and all that this involves at the anthropological level, sociological, design, arts, vision, neuroscience, and all the sciences that observe, study and show interest in the fields of colors. One of the objectives of this study is to be able to extend these two concepts immensely, therefore, to reposition them also in what they are, and bring new conclusions, new ways of looking at the world, bring new interpretations, new solid knowledge, about these two definitions between colors and not the simple fact that static colors are cold colors and dynamic colors are warm colors, as it is established today. The main object in study, represent a group of *dynamic colors* composed by inorganic pigments. These pigments can also be transformed into *static colors*, from their static base, i.e. produced by humans, when we collect the pigments and process them in some way, catalog them in natural tonalities, or mix them with other materials / other pigments in order to create specific colors that are "humanized", from a human intention. Therefore there is a special magic, in these transformation processes. Between the group order, or the isolated color, and the order of symmetry, the colors together and merged in nature.

Serlumen is a new state of being for human evolution. It is a holistic understanding at mental, spiritual and soul levels, on *From Self to Wholeness, From micro to Macro and From Local to Global*. This state of being it is compromising of taking care of the people, taking care of the Earth and taking good care of a sustainable economy. It is focused on 5 pilars of action: *Observing the Potential*, *Connecting the Dots*, *Developing Sustainable Solutions*, *Validating Complex Models*, *Replicating Regenerative Systems*.

7- A New Mindset & Social Model – Self to Wholeness – Local Action for Global Change

These are phenomena that in turn become aware and understood, can generate more quality of life, more understanding, more knowledge, more security, and it is with this certainty that I have as main objective to discover more about all these aspects, and to devote myself to these subjects of *static colors* and *dynamic colors*, as a larger and humanitarian mission. I believe that if there is a common language in this sense, there will be more people who will communicate, and understand the messages that come through color. Thus we observe several points and lines of convergence, as well as several paradoxical scenarios, which show us an enormous richness and arouse even more curiosity about all the knowledge that is called into question and discovered, as well as contributions that can bring, as well as theoretical and practical uses to the various sciences, areas and sectors of human life. We have been creating and developing projects of **ecological paints**, **ecological dyeing** and **ecological mortars**. We have carried out various tests and prototypes in these fields of study, recorded in photographs, videos, drawings and other forms. As a strong contribution to various areas, through this study we intend to open horizons in the world of Eco-Design and Design Thinking. We have as a starting point for all areas and tranversal to the whole study, a great goal, which is: **reconnect people with nature**. Generate autonomy in the use of natural pigments, and in the production and understanding of colors, at the individual and collective level. Open new perceptions to understanding the universe of colors and how they behave in nature, and in the human world. And also enhance new opportunities, solutions, innovations, and new social businesses. Our contribution to the discipline of colors, by bringing other areas of knowledge, and realizing from the ancestors in Greece, the philosophers of Alexandria, and the great thinkers who made history and opened new paths to the human mind, to this day, adding new possibilities and new paths in understanding about colors, through the creation of a new concept, for *static colors* and *dynamic colors*.

It is intended that the Eco-Designer gain knowledge through this research, gain more decision, planning and design capabilities. Gain the ability to design better, with more value and add value in different challenges and social contexts. And that can also emerge organic processes, natural processes combinations between *static colors* and *dynamic colors*, new studies on color in the area of Design, and new strands from these perceptions created. Important for Eco-Design is to understand where the colors come from, how they get to the design process and the application for example, of a product. How can we create our own inks? How can we draw objects that are by themselves dynamic objects, that is, objects that change their shape and color over time in an automatic way, such as living beings. Replicating the language of nature, impermanent. How can colors that are static suddenly be dynamic to the human eye? How to enter this language of nature, dynamic colors, rainbow? How can a Designer create a rainbow? In a deep sense of the word and its essence where a rainbow represents the bridge between Earth and Heaven.

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FIG 3 – flower of life – from earth to sky , mural made by live with earth organization, august 2021

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11. Color and Communication/Marketing

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The psychological association between product's color and consumer's color preference in marketing

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Abstract
In our daily lives, we are constantly exposed to many stimuli, some of which influence our behavior without our full awareness. One of these stimuli is color, which interact with our individual color preference. Color preference influences us in various daily tasks. For example, people make decisions within 90 seconds of their first interaction with products, and approximately 60-90% of a product's evaluation is based solely on its color characteristics. At this point, it is necessary to put color preference at the center of marketing strategies. However, there are few attempts to unify the literature on the contribution of different color characteristics and the role of consumer attributes. This paper is aimed at reviewing contributions that focus on the use of color in marketing and identifying key features and limitations. Practical implications and future directions of this research area are outlined. The results obtained are useful both for basic research and for companies that want to take an informed approach to the use of color.

Keywords: Psychology, Culture, Color preference; Color perception; Marketing.

Introduction
It is now known that people make a decision within 90 seconds from their initial interaction with a product. Approximately 62-90% of the evaluation is based on color alone (Singh, 2006). Optimizing the use of color in marketing is of paramount importance today, and, until now, different techniques have been employed to investigate color influence on consumer choice more accurately (Shaw & Bagozzi, 2018). To date, defining the term "color," giving a definition that is acceptable to all involved, is a very difficult challenge, as it incurs methodological errors or incorrect definition of the stimulus (Bortolotti et al., 2022). In defining or fully understanding the phenomenon of color, it is important to distinguish two characteristics, the first concerning the physical nature of the stimulus encountered, while the second related to the response of the individual who encounters the color (Hunt, 1978). In this latter case, color can be described as that perceptual phenomenon present in everyday life, capable of influencing our mood and our behavior based on the emotions it arouses (Babin et al., 2003; Yildirim et al., 2011). At this point studying color preference, becomes crucial for the vast majority of "social subjects" (Plack & Shick, 1974). Furthermore, traditionally the lack of scientific publications on the use of color in marketing is linked to the fact that research and results in this field have been kept to individual companies in order to gain an economic advantage over competitors (Bellizzi & Hite, 1992). More recently, different studies tried to investigate the individual difference in color preference based on gender (Wilms & Oberfeld, 2018) or context (Palmer & Schloss, 2010). That said, the use of color in marketing is far from obvious and its application is not universalizable. For example, in marketing, inappropriate choice of product or package colors may lead to strategic failure (Czinkota & Ricks, 1983), and in this case, an important role is played by the context and culture of reference (Elliot & Mayer, 2012). Today, however, there are still conflicting results on the contribution of color

preference in marketing. The aim of this contribution is to review the available literature by classifying the articles according to the color and/or consumer characteristics used as independent variables, as well as according to the area of application (e.g. branding, packaging, etc.). The aim of the work is to show how consumer color preference is a fundamental factor for marketing strategies, as we believe it is one of the most influential variable to consider in this field.

Theoretical Background on Color Preference

In the past, studies on color preference, or theories derived from them, have been described as confusing and conflicting (McManus et al., 1981). Between others, a coherent and complete theory on human color preferences is the "ecological valence theory" (EVT) (Palmer & Schloss, 2010). The EVT incorporates the previously theories but with some differences. Consistent with the theories of Humphrey (Humphrey, 1976) and Hurlbert and Ling's ideas (Hurlbert & Ling, 2007), EVT is based on the premise that human color preferences are fundamentally based on adaptive needs. This ecological heuristic will be adaptable, to the concept of survival, where the color provides a good/bad index of a given object, these indexes make the survival of the individual easier. By the way EVT also connects to emotion-based theory (Ou et al., 2004) by showing how environmental feedback is necessary for learning-based heuristics, and color preferences are provided by the emotional results of color-relevant experiences throughout a person's life. The EVT implies that the average preference for any color on a representative sample of people should be largely determined by their average effective responses to their correspondent's colored objects. The more pleasure and positive affect an individual receives from experiences with objects of a certain color, the more he or she will tend to appreciate that color. Therefore, people should be attracted by colors associated with salient objects that generally elicit positive emotional reactions and should reject colors associated with salient objects that generally elicit negative reactions. To date, while different theories have been proposed to explain human color preferences as well as the impact of a specific color on individual preference and choices, still existing controversies in literature prevent efficiently applying knowledge about color preferences in marketing strategies (Schloss & Palmer, 2011). The controversies in this field of studies are mainly due to the complexity of two aspects: the color and its properties on one hand (Bortolotti et al., 2021; Cohen, 2004.) and the characteristics of the human being (Schloss 2015), such as demographic differences (gender and age) and cultural differences, little considered until a few years ago (Madden et al., 2000). As previous reviews showed (Labrecque & Milne, 2012), for a long time, studies in this field focused only on color hue, leaving aside other physical characteristics such as lightness (Bortolotti et al., 2022). Given many processes and the number of characteristics related to color, it is not difficult to believe that there is a huge variance in the types of experimental protocols and variables to be taken into account. To better understand how to use color in marketing we will consider different variables, as based on their capability to influence the preference for a given color. The paper is divided very schematically and summarizes the various variables to be considered in understanding the use of color preference, beginning with the physiology of color perception to the various applications of color as an attentional capture stimulus.

Physiology of color perception

Color perception can be described as a perceptive, highly subjective response to light entering the eye directly from self-luminous light sources or, indirectly, from light reflected by illuminated objects (Brainard & Maloney, 2011). Without going into too much detail, color vision requires the presence of at least two types of photoreceptors (cones and rods) with different spectral sensitivity, more precisely, the cones, which are photoreceptors that distinguish in three categories, S (short) cones that are particularly sensitive to short wavelengths, M (medium) cones that are particularly sensitive to wavelengths averages and L (long) cones, sensitive to long wavelengths. The perceptual process, in all its complexity, influences affect, cognition and behavior, but the reverse is also true, i.e., affective, cognitive and behavioral states can influence the perception of color (Elliot & Maier, 2012). It should be kept in mind that this process, being subjective, creates individual differences toward color preference.

Color in Marketing

As we now know, color preference is an automatic mechanism (Kareklas et al., 2014), even if it is very complex to explain, especially when not all the variables involved are taken into account, or more simply when several colors are used in opposition - or - in combination to each other (Deng et al., 2010). The colors and their use seem to be very controversial and certainly not universal (Elliot, 2015; Taylor et al., 2013). The lack of scientific results related to color in the context of marketing has given rise to several speculations, including the private use of results not disclosed by many companies (Bellizzi & Hite, 1992). There have been some advances in research, although from companies in the color consulting industry, although in recent years there has been an increase in research in this field. Although the nature of the experiments is not entirely scientific, the results seem to be generally shared by marketing professionals, which makes the results applicable. The use of color, however, must be diversified according to the context-marketing required, and must consider the characteristics of the individual as important variables. Some of these variables considered are summarized in short paragraphs below in a very concise way.

Color and culture

Culture is the very foundation on which our life and lifestyle are based (Taylor et al., 2013). Asian culture, Middle Eastern culture, European culture, and American culture have rich values that make people living in those counties unique to each other. Culture, is part of a set of beliefs and social norms that an individual respects in part by reflecting himself as part of a group of individuals similar to his beliefs (but often not the same). These cultures retain their beliefs and associations with colors to show the values of each culture individually, this makes the preference for color a culture-dependent factor and not a universal factor (Taylor et al., 2013), although there may be some similarities (Yokosawa et al., 2016).

Color and gender

In marketing, attention must be paid to gender-based differences. In this regard, several studies have been carried out that have found empirical evidence, albeit with some differences between them (Silver et al., 1988; Ellis & Ficek, 2001). In this field, one of the first major discoveries was that self-identified females showed a greater preference for warm colors (red, pink, yellow...) than self-identified males, and males showed a greater preference for cold colors (blue, green...) than females (Helson & Lansford, 1970). More recent works by Hurlbert and Ling (2007), showed that females prefer reddish shades and do not like greenish-yellow tones significantly more than males. But today we are still a long way from defining a gender-based universal color preference and applying it to marketing without doing economic damage to the company.

Color and context

In this case "context" means the entire space, place, and combination with which the color is associated. What is interesting in the field of marketing is how to use color in the most "universal" way possible to obtain purchase increase. This aspect is studied very carefully by psychologists, as in the case of the "theory of color in context" (Elliot, 2015; Elliot & Maier, 2014), which is designed to be a broad model of color and psychological functioning that can be used to explain and predict the relationships between color, cognition, and behavior (Elliot & Maier, 2007). The theory of color in context is based on six main assumptions: (1) color has a meaning, (2) color vision influences psychological functioning, (3) color effects are automatic, (4) color meanings (and related responses) have two sources, learning, and biology, (5) the relationship between perception and color influences cognition and behavior that are reciprocally interrelated, finally, (6) color meanings and effects are context-specific. This theory is the most accredited and comprehensive theory that could be applied to marketing, succeeding in comprehensively explaining the use of color in the appropriate context. although this theory is the most widely accepted its use in marketing is not then a very simple thing, as there are different aspects to consider.

Color in store

With “color in store" we refer to two categories of approaches related to marketing: the first is packaging and the second is the colors used in-store design. As far as the packaging is concerned, the color of the packages attracts consumers' attention, creates aesthetic experiences, and gives symbolic value to the brand (Labrecque & Milne, 2012). The product packaging represents an essential component to communicate the meaning of the brand to consumers. Especially at the time of purchase, the packaging has been identified as the most important vehicle of communication (Van Rompay et al., 2014). Many researchers in the field (Veryzer & Hutchinson, 1998) argue that color is an essential feature of packaging design and is a prominent component of the visual identity of the product (Garber et al., 2000; Labrecque & Milne, 2012). In a similar sense, the literature indicates that the perceptions of consumer categories incorporate specific expectations about the color options that branded packages within a given category typically employ (Bottomley & Doyle, 2006; Labrecque & Milne, 2012). This trend towards categorization creates a kind of the norm for the use of color in packaging. For the use of colors in-store design several studies have examined the use of color in a store and identified how it can affect the customer's stay in the store and the purchase of products, suggesting that color and lighting are important factors in overall purchasing intentions (Babin et al., 2003).. Changes in the physical characteristics of a store were related to the moods, perceptions, and buying time of consumers. Crowley said that color affects both the affectivity and excitement of consumers (Crowley, 1993). Barli and colleagues show how the color influences the time spent in the store and influences the purchasing behavior, for example, the green color increasingly influences the time spent in the store and has positive effects on the purchase of the product (Barli et al., 2012).

Color and brand

According to Hsieh, Pan, and Setiono, (2004) "a successful brand image allows consumers to identify the needs that the brand meets and differentiate the brand from its competitors, and consequently increases the likelihood that consumers will buy the brand". Companies use a brand to create an experience and an association with the main message they want to communicate, and, therefore, color allows consumers to identify the corporate identity. Some companies now live off their colors, an important example is Coca-Cola, just think of Coca-Cola and we immediately think of red, or the opposite, if we think of red and we have to associate it to a brand in an almost automatic way we associate it to the famous brand mentioned above, this is just an example of how color can leave a positive memory on a brand (Caivano & López, 2007).

Color and trend

One of the most difficult aspects to predict for a company is certainly the fashion trend as it is often associated with colors that with the passage of time becomes boring or obsolete (Blumer, 2017). Predicting the color preference for a specific product becomes crucial for companies dealing with trends or time-dependent consumer products. In this regard, different models have been proposed that try to anticipate the preference for a given color. For example, the "Autoregressive Integrated Moving Average" (ARIMA) (Makridakis & Hibon, 1997) or the Artificial Neural Network Model (ANN), a computational model that imitates the structure and function of biological neural networks (Gurney et al., 1997), as it most recently upgraded variation form known as the Extreme Learning Machine (ELM) (Huang et al., 2004).By the way, given the complexity and unpredictability of the fashion trend in the preference for a given color, the models proposed until now appear still inefficient.

Conclusion

The results obtained from the various research in this field are very controversial since some authors believe that the human responses to colors are stable (Amsteus et al., 2015), therefore applicable to everyone, while in reality, several individual differences make the use of color in marketing a very delicate point and not to be underestimated, the responses and preferences to colors vary depending on culture, gender, and age (Elliot, 2015). The problem with research in the field of color in the context of marketing is that the results obtained from scientific work when applied in a more ecological and "real" context are often not confirmed or even denied. Any company before launching a product, opening a store, proposing a new brand, should implement and conclude research related to the choice of colors, analysing the preference of its consumers according to age, gender, and culture of interest. This should be done before launching a product because the wrong choice of color can have a negative and disastrous impact on the image of the product and the company itself. One could think of a "universalization of color preferences" in global/international marketing strategies. In fact, in the historical era in which, the reduction of territorial barriers and the advancement of communications, through the use of the internet, should facilitate the homogenization of color usage worldwide; making it easier for companies to select the most effective color. This hypothesis could be a double-edged sword for companies and consumers, as on the one hand, it simplifies color marketing strategies globally, but on the other hand, it makes all "competing" companies similar, depersonalizing them. Since this is a hypothesis, the extent to which color can become standard for a given geographic point depends on how hard companies strive to adopt such strategies at this time.. In this field, where many purchasing behaviors are of "automatic", neuromarketing tools could be useful to study purchasing behaviors related to the influence of color (Bortolotti, 2022). A "modern change" that needs to be examined with up-to-date research. Undoubtedly, color research is critical to the advancement of marketing and represents a very promising growth area for marketing practice.

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Cultural-aesthetic parameters of color in advertising communications

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Abstract

Since ancient times color has been a symbol, decor, and a means of information. This research on the cultural-aesthetic parameters of color in advertising communications aims at systematizing visual means and defining their complex functional features in the global space. Objective – color as a national resource in ads (the example of Italian, Swiss and Ukrainian posters). The methodological vector of this research is based on an integrated approach, with socio-cultural, axiological, and comparative methods. The problems of advertising are visualization and stylistic tendencies. Originality includes the scientific study of possible solutions in advertising communication, using associative connotations of color images. Color harmony in advertising is interpreted as a dynamic balance of contrasting elements of the visual info media. As an alternative to globalization processes with an aspiration to standardization and assimilation of cultural peculiarities, the process of a nation's self-identification is actualized in ad posters. The balance of national and international features in the advertisement is relevant. The functions of color in advertisements are here considered, e.g., expressive, physiological, emotional, informative, and aesthetic. Research on color in advertising design in a vast cultural context pays special attention to art-aesthetic aspects concluding that the use of visual means in advertising is orientated to a target audience with aesthetic ideals and national color characteristics. The practical value of the obtained results lies in the application of this integrated approach to color education and color designing the Ad posters.

Keywords: color semantics, visualization, ad poster, cultural context.

Introduction

Visual perception is closely related to the semantics of color – not only cultural but also psycho-physiological, because during perception there is a combination of visual reaction and thinking, there is a process of judgments and thoughts. Different levels of significance with the use of color symbols and connotations affect semiological understanding in the construction of self-identification through objects or images. Jean-Philip Lenclos analyzes the world's dominant colors according to his own concept of "color geography", explores the palettes of different habitats and proves how climate, geology, lighting, socio-cultural features and ethno-art traditions uniquely affect the applied aspects of color, its aesthetics (Lenclos, 2004).

Since ancient times color has been a symbol, decor, and a means of information. The colors of nature are inexhaustible sources of inspiration for artists and designers. There are three levels of color perception: 1. Sensing color can be understood as the simplest understanding of physiology; 2. Perception is a more complex process due to a number of laws of psychological nature; 3. Sense of color belongs to the emotional-aesthetic sphere. This research on the cultural-aesthetic parameters of color in advertising communications aims at systematizing visual means and defining their complex functional features in the global space. **Objective** – color as a national resource in ads (on the example of Italian, Swiss and Ukrainian posters). Color is always and everywhere a manifestation, an expression of a certain idea, however, not a measure of quantity or form, but the quality of the property without which it is impossible to imagine human intelligence. The colors of culture are created by Man, and visual culture, in turn, creates Man. In this case, we focused on the practical application of national colors in the posters. The relevance is due to the importance of color graphics in the fields of commerce, industry, culture of many countries, and intensification of visual researches. At the beginning of XXI cent. great changes happened in conception of design and advertising because of the globalization processes and simultaneous ethno-cultural identification. Color in many varieties of art, design and advertising performs important aesthetic, formative, and informative tasks. The genesis of color in advertising communications determined by several factors: first – a pragmatic, depending on the existing inventory of economic relations, development of media and specific commercial objectives; second – a cultural, depending on the socio-cultural realities of society forms and psychological aspects of national mental groups. And third factor – aesthetic, depending on the ideological platforms and art-historical processes of development, affecting the transformation of social structures, spiritual and material culture, and on the formation of art styles. So, color always needs the certain context (Pryshchenko, 2018).

Methods and visualization in Advertising

The methodological vector of this research is based on a integrated approach: socio-cultural, axiological and comparative. Visual language of advertising design is represented by logical reflection on the sociocultural state of a society during definite periods. The aim is to characterize the problems of advertising communication in a cultural context such as visualization, stylistic aspects, and development tendencies. Originality includes the scientific study of possible synergistic solutions in advertising communication, using associative connotations of artistic images and creative figures (e.g., hyperbole, metaphor, allegory, association, and metonymy) impacting the complexity and leading to an overall effect which is much greater than the sum of each. Some authors studied the color forms in advertising communications (Barnard, 2005; Colour Design, 2017; Heller, 2000; Singh, 2006; Thiessen, 2017). Our vision of the problem is that advertising is trans system, integrative character, and the multimodal approach has proven to be the most appropriate for understanding the nature of advertising communications. Methodology is based on socio-cultural, axiological and comparative methods to the analysis of visual language of color in ads. The socio-cultural method made it possible to interpret color graphics as a reflection of the historical, cultural, economic, technological and political stages of society. Applying the axiological method, color considered as a derivative product of culture, due to a set of needs, values and norms of a particular historical period. The comparative method provided a comparison of the advertising in historical dynamics. The theoretical fundamentals for color research are scientific publication (Biggam, 2012) and advertising design research are publications (Advertising and Art, 2007; Binder, 1934; Flath & Klein, 2014; Meggs, 2006). Anatol Wowk examines the national palette, noting that the color designations in the Ukrainian language have a very wide range, and in particular, the pair “blue-yellow” in the Ukrainian flag has the following color interpretations: light blue, greenish-blue, navy blue, azure, strong blue – and springy, spring orange-yellow, golden-yellow, warm yellow, yellow chrome. Therefore, even at the level of use in the design and advertising of the pair “blue-yellow” quite significant variations of shades are possible (Wowk, 1986). Little researched remains visual-verbal code of advertising communications. Advertising becomes a sign that sells not a product itself but its symbolic reflection. Moni Almalech emphasizes that the semiotics of color combines visual and verbal aspects that are very important in advertising – natural prototypes, universal meanings, associative characteristics, ethno-cultural features, manipulative strategies to influence the consumers (Almalech, 2011).

To aesthetic parameters such as color-tonal contrast, color harmony, limited color palette, integrity of the composition, originality of the advertising idea, comprehensibility and informativeness of the advertisement, brevity of visual information, presence of photographs, computer special effects, and technical quality of the execution of advertising image, we add the presence of certain stylistic features, in particular ethno-stylistics and national coloristics, in the construction of Ad appeal that generally gives good reason to consider them **cultural-aesthetic parameters**.

Functions of color in ads

Florian Yuriev, selectively considering the color symbolism of different times and peoples, believes that all symbolic systems, without exception, contain semiotic signs of broad generalized meaning, which were used by philosophers, theologians, scientists, and artists. For any language, the main ones are semantic units that are similar to the characteristics of the object or concept, and in a particular situation acquire cognitive (cognitive) values, the value of which is determined from the standpoint of national color culture. As a color metaphor, associative-code meanings have expressive significance not only in painting, but also in the art of visual information. From the point of view of semiotics, color performs three functions: communicative, cognitive and expressive. At the stage of representation in the process of perception with the help of color, communicative stages take place: distinction, distribution, separation, and unification of visual elements. At the stage of color-coding objects of reality or concepts, a cognitive function is performed. And already at the stage of emotional expression of feelings and aesthetic evaluation, the expressive functions of color are performed. In a real information situation, there are always nuances of color preferences that have a very subtle effect on the art imagery (Yuriev, 2007). To our mind, color perception in advertising has strong psycho-emotional, associative and semantic principles, which are based on physiological, archetypal and historical-cultural levels. In the era of "emotional shopping", color is becoming a powerful psychological tool to influence the consumer. The design features of advertising must be considered in the design process. Hierarchically, it looks like this: at the first, emotional level, the main thing is the expressive function (which is the last in Yuriev, with which we can`t agree), at the stage of attracting attention, psycho-physiological – at the stage of perception of objects and generalization of forms to simple geometric figures, emotional – at the stage of perception of straight and curved silhouettes in tone and color. At the second level of logical analysis, the informative function is added – at the stage of formation of consumer interests, and aesthetic function – at the stage of readiness to purchase purchases. Image advertising is becoming increasingly important, which, in contrast to the narrow approach as a one-way appeal, campaigning for specific goods or services. A broad approach is aimed at any appeal of the manufacturer or seller to the national colors of the target audience (Pryshchenko, 2018, p. 262).

Based on the comparative analysis of advertising images in the different times, we have identified the four chronological stages in the choice of color as a style element and national resource in Italian, Swiss and Ukrainian posters (Fig. 1–4). Every country has its own cultural traditions, but a lack of respect ruins the strategy of ads.

A figurative stage was the most prolonged, purely, advertising than didn`t differ much from the works of Fine Art: realism, classicism, and ethno-stylistics in the XVIII–XIX cent. In the given examples we clearly see folk costumes that are organically entered into advertising themes (Fig. 1).

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Fig. 1 – a) Italian liqueur, Milano, 1890s; b) Swiss Milka ads, 1980s;
c) separator ads, Riga-Zhitomir-Chelyabinsk, 1890s (free access from www.pinterest.com)

A formal stage, one founded on the use of Avant-garde means, mainly the simple and contrast color combinations of functionalism from Bauhaus style in European countries, and Ukrainian constructivism, suprematism with ethno-stylistics in the first half of the XX cent. (Fig. 2). These examples already have signs of national colors as visual identifiers of countries.

Fig. 2 – a) Vintage Italian ads, 1930s; b) Swiss travel poster, 1949;
c) Vasil Yermilov. Ethnic motifs in the package, 1922; d) "Intourist" poster from the Soviet era, 1930s
(free access from www.pinterest.com)

A synthetic stage combined various color means of previous stages. Postmodernism captures all spheres: eclecticism, fragmentation and strategic instability, ethno-stylistics, the complexity of images, and its deconstruction in the II half – the end of XX cent. For example in Fig. 3,a-b we see rather bold use of the colors of Italian and Swiss flags, but for the poster (Fig. 3,d) the artist chose the traditional colors for Ukrainian embroidery – black, red and white. In Fig. 3,c the image of a woman and blue-yellow colors are very similar to Ukrainian.

Fig. 3 – a) Italian exhibition poster, 1967; b) Bata, Peter Birkhauser, Switzerland, 1944;
c) Celebration of European diversity. Ad brochure for the department store "Globus". Zurich, 1955;
d) Volodymyr Lesnyak. Ukrainian Folk Week, 1982 (free access from www.pinterest.com)

An imagery-associative stage, in which the art image, emotionality and originality of the chosen visual means are put forward. The rise of postmodernism, and conceptual search for new styles, returning ethno-style (neo-folk), functionalism and minimalism, pin-up, leading polystylism. Color becomes a significant visual channel for communication, flat colors and shapes, the decor is absent, and big possibilities of computer effects in early the XXI cent. These four posters vividly demonstrate the dominance of national colors in Ad (Fig. 4). Nowadays take into account the specifics of regional cultures and their inherent graphic and color means of expression. Archetypal images in ads often imitate folklore motifs, themes, ideas, and characters. The frames of postmodernism are widening; forming of new stylistic trends in Architecture, Art, Design and Advertising are made by deliberate synthetic approach in the use of variable elements, wide spread of irony and giving new context to old forms, complexity of the sense of harmony, increasing the variety of genres, reinterpretation of ethno-art traditions, accepting the coexistence of different cultures and their dialogue.

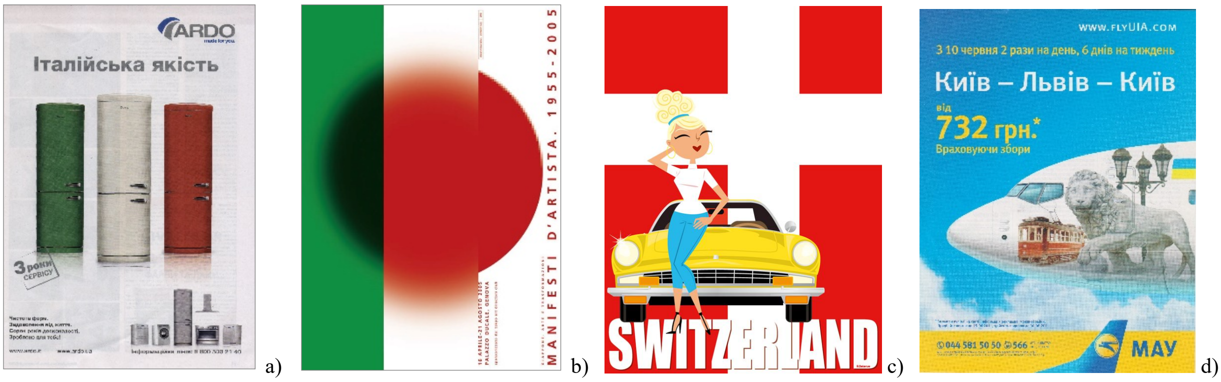

Fig. 4 – a) Ardo in Ukraine, 2008; b) Art Manifest, 2005; c) travel poster by Raphael Delerue, 2015; d) Ukraine International Airlines, 2005 (free access from www.pinterest.com)

Color harmony in advertising is interpreted as a dynamic balance of contrasting elements of the visual info media. As an alternative to globalization processes with an aspiration to standardization and assimilation of cultural peculiarities, the process of a nation's self-identification is actualized in advertising. Negative phenomenon of pseudo-nationalization was formed and consolidated at that time (e.g. pseudo-Ukrainian, pseudo-Russian, pseudo-Japanese, pseudo-Eastern styles). Though, the use of ethno-motives in advertising graphics should not be the "decoration" of advertising products, but it should be looking for new national forms of ads, saving regional cultural values in modern life, because accelerated speed of globalization brings world to obliteration of boarders (Pryshchenko, 2012). Advertising evolved from illustrative accompanying of commercial information to appearance of new to the appearance of new styles (or pseudo-styles) in frames of mass culture of end XX – the beginning of XXI cent. In this context a lot of mistakes in advertising graphics were exposed: prevalence of stereotypes, primitivism, vulgarity and the absence of national imagery of major countries. Nowadays in the advertising are dominated pop art, kitsch, eclecticism. But advertising products for mass consumers must have aesthetic level and implement cultural and educational functions.

Conclusions

Therefore, we believe that our proposal brings interesting, useful, and important information about color as a means of advertising communication to this event. The functions of color in advertisements are here considered, e.g., expressive, physiological, emotional, informative, and aesthetic. Research on color in advertising communications in a vast cultural context pays special attention to art-aesthetic problems concluding that the use of visual means in advertising is orientated to a target audience with aesthetic ideals and national color characteristics. Color contributes to the national identification and image creation of countries, producers, goods, and services. Thus, the aesthetic parameters of color in advertising are defined as cultural-aesthetic, since they always have semantic, communicative, and cultural implications. The practical value of the obtained results lies in the application of this integrated approach to color education and color designing the Ad posters.

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Go Somewhere Glossies: Experiential Color in Magazine Design

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Abstract

Color-laden, imagery-driven magazines—otherwise known as “glossies”—have seen dramatic increases and decreases in readership in our digital age. In many markets, the global pandemic caused a spike in magazine shopping and consumption, and bookazines as typology—“single-topic deep dive magazines”—trended (Topic: Magazine Industry, 2022) (The Magazines People Have Been Reading During the Pandemic – WWD, 2022). This paper provides an in-depth examination of the design process of creation of a two-volume travel magazine publication designed to convey the haptic experience of color.

Keywords: color and publication design, color and material, color and culture, color and environment, haptic color, magazine design.

Introduction

> ...our skin is actually capable of distinguishing a number of colours;
> we do indeed see by our skin.
>
> *Maurice Merleau-Ponty, The Visible and the Invisible, 1968*
> *(Merleau-Ponty, 1968)*

> With 24/7 streaming commonplace, and our attention spans shrinking from distraction, physical space needs to up its game… We need spaces and materials that delight and engage the senses, utilizing extreme texture, deep surface relief, and high touch. People want to connect to where they are, or we will lose them to the internet.

Design Director and LEED eco-certified designer Royce Epstein, “Losing Touch, Getting Tactile” for Wanted Design at New York Design Week, 2018 (Epstein, 2018)

Methodology

The design process involved the following series of steps:

1- Define the mission of the international study project
2- Research and coordinate preliminary schedule and events
3- Implement months of travelling, learning, and experimenting
4- Reassess plans for design outcome as the pandemic caused a shift in location
5- Ideate to identify new design opportunities
6- Select magazine design as final project deliverable
7- Implement design of magazines (with multiple levels of iteration, mock-ups, drafts, and edits up until printing). The documentation of haptic color in the magazines took the form of photographs as visual essay of materiality and color, written text, layout (including typography choices), and detailed color charts of the vernacular materials of Mexico (and Argentina) as seen in Fig. 1, Fig 2, and Fig 3.
8- Evaluate project and process (and include preliminary evaluation at conclusion of magazines)
9- Print final magazines
10- Hold and experience the haptic interaction with the magazines
11- Re-evaluate and find opportunities to finesse for possible future editions of the magazine

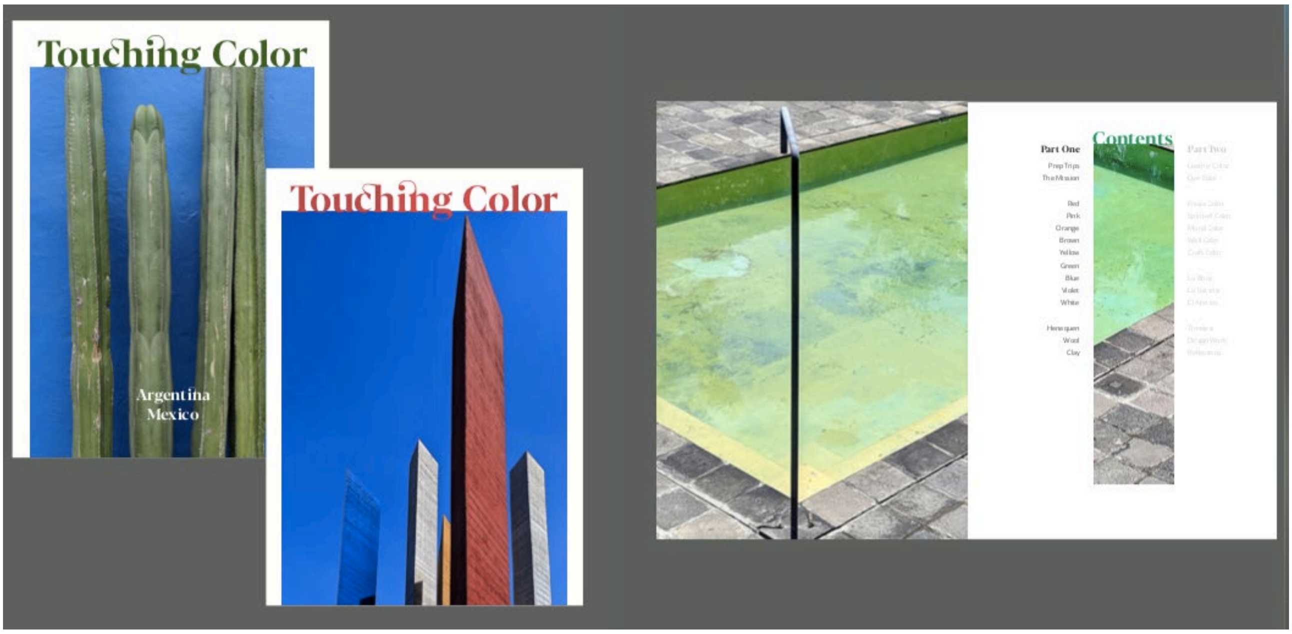

Fig. 1 – Volumes I and II covers and Volume I content pages from *Touching Color* magazines

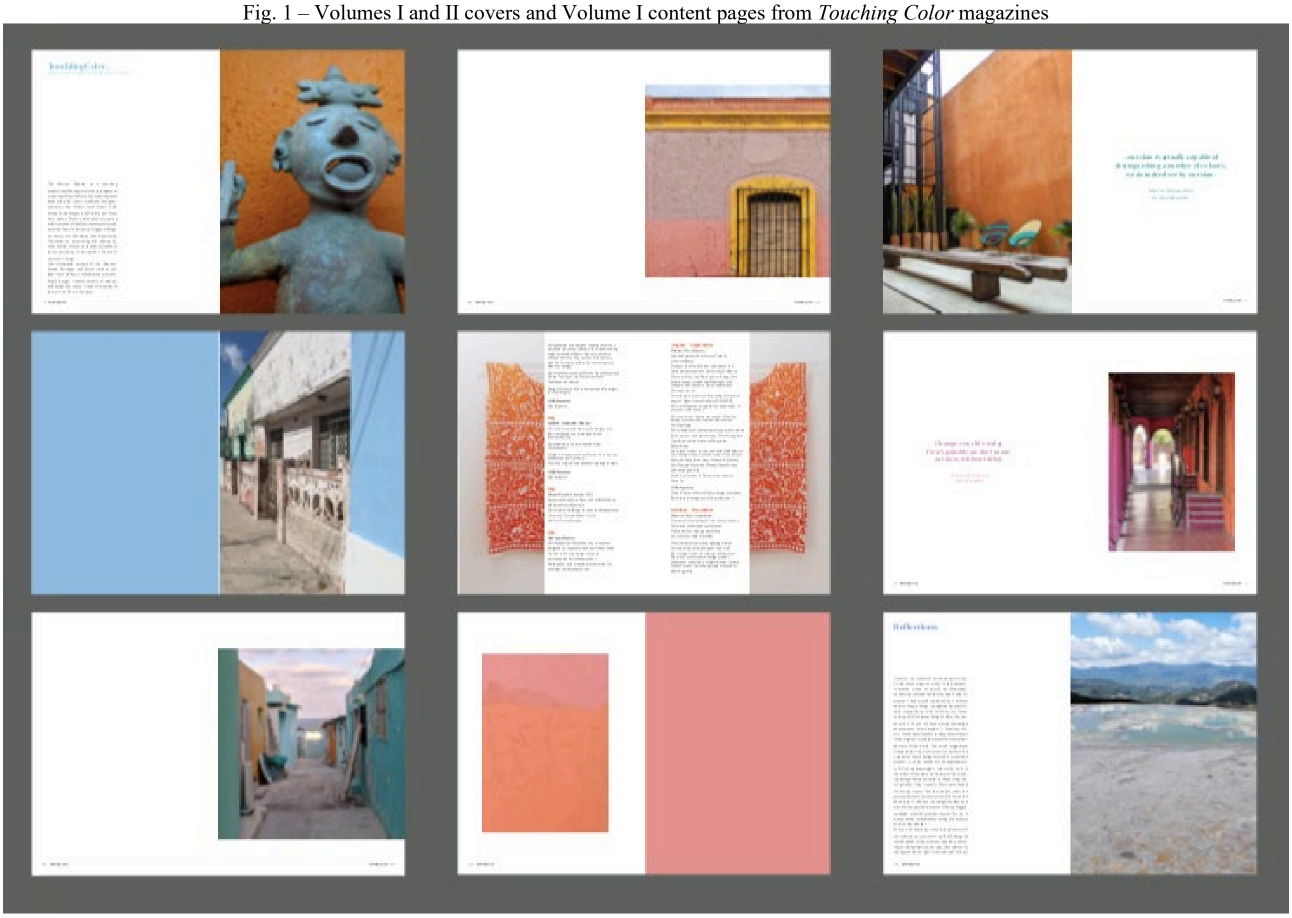

Fig. 2 – Select interior spreads from *Touching Color* magazines

The Mission

Embark on a year-long exploration of design in relation to indigenous material of Mexico. Work, live, and visit places frequented by iconic modernist designer-educators Anni Albers, Josef Albers, Ruth Asawa, Luis Barragan, and Clara Porset. Meet local makers fluent in techniques of creating with materials of the Mexican vernacular and examine formal elements of regional design on visits to pre-Columbian sites. Importantly, the hands-on researching, making, and documenting on site were to focus on the haptic (sense of touch pertaining to perception and use of objects) in design using color.

Fig. 3 – Select interior spreads showing color charts in *Touching Color* magazines [At left, Mexican dye materials from left to right starting in upper left to finish at bottom right: nettle, cochineal, rock moss, huizache resin, tampico fiber, indigo, brazilwood, marigold, achiote (from seeds of the evergreen tree), tree moss, brazil stick, and casahuate mushroom. At right, an assortment of natural colors of leather hides from Argentina.]

Fundamental Artist-Designers in Project Concept

The intertwined network of Anni Albers, Josef Albers, Ruth Asawa, Luis Barragan, and Clara Porset served as ideal case study for this examination of the haptic use of color and material.

During her career as a weaver, designer, and printmaker, **Anni Albers** fundamentally shifted the perception of "women's crafts" and launched some of her century's greatest advances for women in creative careers. She was a student and then director of the weaving division – the only department open to women at the time – at the progressive, experimental Bauhaus design school.
She blended handcraft and industry to create one of the Bauhaus's only financially successful divisions and, in so doing, played an integral part in the legendary design institution's vision as a lab for innovation in industry. She – along with her husband Josef Albers – taught and created with a strong emphasis on experimentation with materials, a core component of Bauhaus philosophy. In her book, *Material as Metaphor*, Anni explained that "material is a means of communication…" (Josef and Anni Albers Foundation, 2022). One of Anni's former students shared, "The important lesson I absorbed was that you do 'listen' quietly, threads would suggest what could be done with them… This instruction slowly allowed possibilities of the materials to reveal themselves" (Josef and Anni Albers Foundation, 2022). Back in 1965, surrounded by a society of sleek-surfaced modern cityscapes, Anni mourned the paucity of tactile experience:

> We touch things to assure ourselves of reality… Our tactile experiences are elemental. We are apt today to overcharge our gray matter with words and pictures… and to fall short in providing for a stimulus that may touch off our creative impulse, such as unformed material, material 'in the rough' (Albers, 2000).

Anni's work demonstrates her philosophy as her rugs, acoustic wall hangings, and textiles (designed for production with reputable institutions such as Harvard University and Knoll manufacturing) overflow with textural richness in rare combinations of materials often pushed to their limits (Dickson, 2017).

Josef Albers used the term "matière" to describe the inherent properties of material, which he found to be of fundamental importance in creation of art and design. One of the world's most influential color educators and a key artist of the twentieth century, Josef attested that "the great discipline of the Mexican sculptor… teaches us… Be truthful with materials" (Hinkson, Barriendos Rodríguez and Albers, 2018). For an exhibition titled "Josef Albers in Mexico," New York's Guggenheim Museum noted:

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> For Josef, the complex abstract vocabulary of pre-Columbian art and architecture embodied the principles he and Anni espoused in their work and teaching. With limited knowledge of the cultures that had built the structures they admired, the Alberses celebrated those civilizations' dynamic geometric forms and truth to materials—values the couple sought to renew in modern art and design (Josef Albers in Mexico | The Guggenheim Museums and Foundation, 2022).

Experts today reiterate this sentiment stating the "profound link between the art and architecture of ancient Mesoamerica and Albers's abstract works on canvas and paper" (Josef Albers in Mexico | The Guggenheim Museums and Foundation, 2022). As seen in his interpretation of vernacular adobe doors, Josef directly brought Mexican forms and colors into his abstract color field paintings. The comprehensive book, *Small-Great Objects: Anni and Joseph Albers in the Americas*, underscores this practice by pairing images of the Albers's extensive collection of pre-Columbian objects with formal elements in their creative work that reflect the same pre-Columbian massing, imagery, and material (Reynolds-Kaye and Coe, 2017). In 1933, Anni and Josef—like many other illustrious Bauhaus artists designers—left Germany due to Nazi pressure and taught at newly founded avant-garde Black Mountain College in North Carolina. Others living and working at Black Mountain College included creative achievers such as composer John Cage, choreographer Merce Cunningham, and architect Buckminster Fuller. While the Alberses were in residence, Ruth Asawa and Clara Porset were also students at this progressive school (The Story of Black Mountain College—and a Look at Its Continuing Legacy - Charlotte Magazine, 2019) (Reff, 2017).

With persistence and fortitude, California-born **Ruth Asawa** found creative opportunities in improbable situations. During grueling hours of working on a farm as a young child, she "drew" by dragging her feet in the dirt while riding on the back of farm equipment. This low-tech, highly haptic interface enabled her to discover organic forms that she continued to use throughout her life. Forced into Japanese American internment camps as a teenager, Asawa continued to draw, this time with Walt Disney animators interned along with her. Years later, racial discrimination halted her chosen career as a teacher, so friends suggested she move to Black Mountain College. The Alberses figured strongly into Asawa's life after her arrival at Black Mountain, and Josef Albers became one of her lifelong mentors. Curators find Asawa's work to be "firmly grounded in [Josef 's] teachings in their use of unexpected materials and their elision of figure and ground" ("Ruth Asawa Press Release", 2018). Josef's lessons on matière sparked Asawa to travel to Mexico where an egg basket maker introduced her to wire as creative material. Asawa proclaimed, "The artist must respect the integrity of the material. I realized that I could make wire forms interlock, expand, and contract with a single strand because a line can go anywhere" ("Ruth Asawa Press Release", 2018). She applied this regional making method to conceptually modern work. She pushed properties of wire, painstakingly looping it into seemingly airy and weightless forms counterintuitive for metal as material. Her innovations brought fame in exhibitions at venues such as the Museum of Modern Art and the Whitney Museum of American Art. Asawa lived at Black Mountain College amongst resilient women, such as Anni Albers, who showed her that life as a female artist was indeed possible. Named to the Council of 100 Distinguished Women Artists in 2001, Asawa was a working creative, wife, and mother of six. She also left her mark as an activist for art education and social change, creating innovative schools and serving on prestigious organizations such as the National Endowment for the Arts ("Ruth Asawa Press Release", 2018) (Home - Ruth Asawa, 2022) (Hatfield, 2017) (Ruth Asawa, n.d.).

Like Anni and Asawa, Clara Porset was fueled with an obsession with materials and making in Mexico, and her work elegantly melded the traditional and the modern in the Mexican vernacular. Porset studied under the Alberses at Black Mountain College and became a vital part of their creative lives, travelling extensively with them in Mexico where she worked for many years. Like

Anni, Porset delighted in merging “the industrial and the artisanal,” curating a ground-breaking exhibition that shocked visitors by juxtaposing historic artifacts of artisans of Jalisco and Michoacan with modern designs produced in Mexican factories. Porset worked with local makers and her work alluded to traditional craft in Mexico. Her most famous design redefined the archetypal “butaque” chair – historically crafted in artisan workshops in the Yucatán and Veracruz – to be more comfortable, ergonomic, and modern. Porset’s persistence opened unprecedented opportunities to work with major players in the male-driven design scene in Mexico; in so doing, she advanced the role of women artists and designers in general (Noelle, 2012) (Rawsthorn, n.d.).

Porset collaborated with the likes of Guadalajara-born **Luis Barragán**, the quintessential Mexican modernist architect and winner of architecture’s acclaimed Pritzger Prize. He transformed the sleek, single color surfaces of the International Modern movement with the integration of vernacular hues of Mexico and with use of textural material, massing, and imagery of Mexico’s pre-Columbian architecture. His colorful tactile-rich house and studio, Casa Luis Barragán – situated in Mexico City where he practiced for most of his career – stands chromatically proud as a UNESCO World Heritage Site. Of note, Barragán met Josef Albers in the 1950’s (Biography: Luis Barragán | The Pritzker Architecture Prize, 2022) (O'Leary, 1995).

The Alberses, Asawa, Porset, and Barragán travelled, worked, and created together, and their history-making careers were strongly influenced by the landscape, archaeological sites, and native materials of Mexico. With the enduring heights of their design achievements, legacy-making passion for education, and delight in Mexican craft and material exploration, these five artist-designers forever changed the design landscape and reside in the ranks of the twentieth century’s creative elite.

Influence of the Haptic

In a foundational study in their book, *Body, Memory and Architecture*, Yale professor Kent C. Bloomer and architect Charles W. Moore argued, “The body image… is informed fundamentally from haptic and orienting experiences early in life. Our visual images are developed later on, and depend for their meaning on primal experiences that were acquired haptically” (Bloomer and Moore, 1979). Today, our society of cell phones and touch screens denies users a true tactile experience. Contemporary scientists work on prototypes of haptic interfaces created with digital technology, developing feedback projects where users can “touch” virtual flowers in the air or feel corduroy textures on a touchscreen (Arion McNicoll, 2013). Scientists admit that they haven’t been able to exactly replicate real touch with digital means. Designers and contemporary scientists agree. Nothing can replace the real thing. Massachusetts Institute of Technology doctoral graduate and computer scientist Karon E. MacLean noted that the tactile, the textural, and the haptic make aesthetic works resonate and live on as classics:

> It is the quality of life-likeness, and of “material significance” that stimulates our tactile imagination. Artworks that embody such qualities survive as masterpieces, whereas ones that do not become merely intellectual or historical curiosities.
> Without volume, bulk, inner substance, and texture, in short without the stuff of touch, the poetry, character, and plot of an art have no anchor in the world, no place for our imagination to take hold... Touch is the “bass line” of art experience (Haptic Interaction Design for Everyday Interfaces”, 2022)

Again, designers concur. In spring 2019 (at the start of this research project), cutting-edge designers debuting their wares with crowds of influencers at their heels converged on the streets of New York City for the annual International Contemporary Furniture Fair. Here, a panel (aptly dubbed “Losing Touch, Getting Tactile”) sounded a call for an increased textural experience in our physical environment to counteract the digital screen-centric lifestyle that reigns today (Epstein, 2018). Designer Royce Epstein argued,

> … the hand is coming back into the process… as we become more immersed in the digital era, the role of materials and tactility is taking on greater importance than ever before… now that we all communicate through glass screens on our devices, we are losing our sense of humanity and thus craving creature comforts. As such, materials are becoming a crucial interface to the human body and how we experience the built environment (Epstein, 2018).

Sales numbers back these theories; our touch-starved population devours tactile items trending in the market: rough linen sheets, fur pillows, and textural tiles are just a few examples. By September 12, 2018, Instagrammers had hashtagged "tactile" 65,063 times. As of July 7, 2022, there are 160,433 posts with #tactile (https://www.instagram.com/explore/tags/tactile/). Many iterations of tactile-based hashtags appear as well such as, on July 7, #tactileart 17,468 posts; #tactilelearning 11,722 posts; #tactiledesign 6,720 posts; #tactiletypography 3,235 posts; and #tactilelettering 1,792 posts (#tactile hashtag, n.d.).

Sequence of Events and Locations in 2019 and 2020

January (Prep Trip Two)—Mérida, Yucatán to make initial contacts and research color, material, and site

April (Prep Trip Two)—Guadalajara and Zacoalco de Torres, Jalisco including participation in a collaborative furniture design ideation and research trip and a visit to authentic "equipales" typology chair fabricators

June—Oaxaca, Mexico including participating in a natural dyeing workshop with master weavers and a printmaking workshop with local artists, visiting Mitla and Monte Alban archaeological sites (which were places of inspiration for Anni Albers), and visiting artist shops and studios working with local materials such as barro negro (black clay)

July—Mexico City including tours of works by Luis Barragán; Saltillo including visiting the tile factory where my tile designs are fabricated and touring the original serape shawl making factory; the Oaxaca coast including a visit to the modern design compound Casa Wabi

August to September—Mexico City including living and working with artists at Casa Lü artist residency and researching at the Clara Porset archives at the National Autonomous University of Mexico

September to December—Buenos Aires, Argentina including presenting at the International Color Association's Color and Landscape conference, taking a leather making workshop, and working with a local glassblower and a furniture designer to create collaborative works

February to March—Yucatán, Mexico including documentation of colors and materials of region, visiting archaeological sites (such as site Uxmal frequented by the Alberses), visiting a working henequen hacienda factory, and working with local wood fabricators

March to August—Cancelled remaining travel plans due to pandemic and moved back to the United States. This shift in plans afforded the opportunity to change the final project format from solely making physical pieces of design with local makers to synthesizing my trip by designing the Touching Color magazines.

Conclusions

Site-specific investigation into the Alberses, Asawa, Barragan, and Porset offered a viable means to analyze how haptic qualities of indigenous materials of a region shape and inform creative work. These investigations revealed how creators use inherent hues and properties of vernacular materials to best advantage with, often, a fusion of historic techniques and contemporary modes of design.

Additionally, while crafting creative works with local makers, the potentials of the collaborative creative experience, multicultural learning as a design tool, and influence of landscape and local traditions in design were brought to life. Creation of the magazines forced a synthesis of concepts surrounding sense of place, traditional craft of region, haptic effects of vernacular material, influence of multicultural networks and collaborative practices, and design precedents in the regions that can inspire future directions of designing, teaching, and learning. And, finally, the magazine design offered confirmation of the counterintuitive idea that it is possible to convey haptic color in a tangible format away from the actual material depicted. Although all do not have the opportunity to travel to colorful spaces away from home, the Touching Color magazines allow readers opportunities to – so to speak – flip, feel, and fly with haptic color around the globe.

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12. SPECIAL SESSION: Color for beauty, cosmetic and hairstyle

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Mineral pigments in make-up products : classification, formulation and sensorial properties

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Abstract
In make-up products, pigments are used to bring color. They are also found in soaps, toothpastes, high Sun Protector Factor (SPF) sunscreen products to create a physical screen... Two categories of pigments coexist: mineral (or inorganics) pigments and organic pigments. In many cosmetic products, only mineral pigments are tolerated if we consider all international regulations. This is the case for eye products and foundations. Mineral pigments have many advantages: beyond their claim of naturalness on which they surf excessively, they are remarkably stable in formulations with a few exceptions. In addition, their opacity gives them an important coloring power much appreciated by formulators. In this article, we will see how mineral pigments work, the cosmetic regulations that govern their use, their classification, their physical principle to appear colorful. A presentation of the properties of each of them in formulation will be made. Finally, each of these pigments has a variable chemical composition and physico-chemical characteristics and we will see how each of them impacts the sensorial properties of the make-up textures into which they are introduced.

Keywords: mineral pigments, inorganic pigments, cosmetics, make-up, sensoriality

Introduction

In cosmetics, dyes are used to color lotions, shower gels, perfumes, toiletries and creams. They do not color the surface of the skin and remain transparent like syrup. They are soluble and dissolve completely in the medium into which they are introduced, losing their crystalline structure. In makeup products, where visible color is expected after application to the skin, pigments are used for coloring. They are also found in soaps, toothpastes or in high SPF (Sun Protector Factor) sunscreen products to create a physical screen with a white pigment... They make the formulas opaque and color the medium on which they are applied. They are insoluble in the medium into which they are introduced, hence the essential step of grinding during manufacture. They remain in solid particles and form a suspension. The necessary insolubility of the pigments is achieved by avoiding solubilization of the groups of the molecule or by forming an insoluble organic structure. Two categories of pigments are used in makeup: organic pigments and mineral pigments. It is the latter that interest us for this publication. In the first part, cosmetic regulation, so complex, is discussed. Then, a description of the mineral pigments used is made as well as the formulation constraints specific to each of them. Finally, if pigments bring color to cosmetics, they also modify the texture. All the sensory aspects of a formula are therefore impacted by the pigments introduced to achieve the hue: viscosity, application, makeup result... These aspects are developed in the last part through example of make-up products traditionally formulated with mineral pigments. It is necessary for colorists to know the sensory impact of a pigment within a texture. Indeed, a range of eyeshadows can be composed of more than 40 shades, a range of mascaras 4 to 6. Foundations must offer shades that meet the needs of all skin tones from the lightest to the darkest. This generates foundation ranges with more than 40 beiges sometimes, with similar sensory requirements regardless of the shade. Similarly, within the same range of eyeshadows, pearlescent products like those with a matte finish must also have similar sensorialities. Pigments have behavior that depend on their chemical composition, their particle size, their hardness, their surface condition, the additional presence of a coating etc. This explains why the offer of varied shades offered within the same range leads to differences in sensory experience. These differences are characterized in sensory analysis.

Regulation and regulatory definitions

In Europe, cosmetic dyes are regulated via Annex IV of Regulation No. 1223/2009 (OJEC, 2008). This is a positive list: if the pigment is mentioned, it is allowed. Conversely, the raw material is not considered a pigment or dye and therefore cannot be used to color a cosmetic product. The European definition given to coloring raw materials is as follows: "Colored dyes or additives are cosmetic ingredients that give color to the skin or dander. They are also used to color finished products." Since 2013, Europe has regulated the use of nanomaterials in the same regulation. To be authorized, one of the dimensions of the pigment particle must therefore not be less than 100 nanometers (nm). If one of the dimensions is nanoscale, the dye must be explicitly listed in Annex IV to the Regulation to be authorized. To date, only Carbon Black is present in Annex IV of the Regulation. Nano-titanium used as a sunscreen is also tolerated because the public health benefit is considered greater than the risks associated with its use. In the United States, the use of dyes in cosmetics is regulated by the Food and Drug Administration (FDA), which publishes the Federal Food, Drug and Cosmetics Act (FDA, 2010; FDA, 2011) incorporating the regulations on containers. The definition given to coloring raw materials is as follows: "Any material which is a dye, pigment or any other substance obtained by a synthesis process or artifice close to, or derived, with or without intermediate or change of final identity, from a vegetable, animal, mineral or other source, and which when introduced into a food, a medicinal product, a cosmetic or on the human body or any of these parts, is capable (alone or thanks to a reaction with other substances), to bring a colored effect". Mineral pigments of natural origin are prohibited: all must be of synthetic origin. In Japan, the use of synthetic dyes is limited by a positive list (Nippo, 1989). The use of mineral dyes is the responsibility of the manufacturers without more specificity than uncolored raw materials. In China, the regulations also define a positive list of permitted colors (IECIC, 2015). For colorists who work in cosmetic groups that export worldwide, the difficulty is to formulate wide ranges of shades whose pigment composition allows international export despite the different regulations (de Clermont-Gallerande, 2021). This requirement to sell the same product worldwide means that only pigments common to all regulations can be used. The level of impurities contained in the pigments are closely monitored. As an example, here are the heavy metal rates imposed by USA and European regulation (tab. 1).

Iron oxides	Pb	As	Hg	Cd	Zn	Ba	Cr	Cu	Ni
FDA	10	3	3	-	-	-	-	-	-
E 172	20	5	1	5	100	50	100	50	200

Titanium dioxide	Pb	As	Hg	Cd	Zn	Ba	Cr	Cu	Ni	Co	Sb	Se
FDA	10	1	1	-	-	-	-	-	-	-	-	-
E 171	10	3	1	1	50	-	-	-	-	-	50	-

Table 1. Standards in ppm (parts per million) of heavy metals for iron oxides and titanium dioxide.

Classification

In regulatory terms, in the United States, it is the chemical name of the pigment in INCI (International Nomenclature of Cosmetic Ingredients) that is mentioned on the packaging. In Europe, the classification is carried out according to a CI (Color Index), assigned according to the chemical nature of the pigments, which must also appear on the packaging. Table 2 presents the classification of the different mineral pigments authorized in cosmetics in order of increasing Color Index and therefore by chemical nature (Faulkner *et al.,* 2021). Colored molecules not mentioned in table 2 are not permitted as pigments. It is therefore a positive list that is necessarily restrictive for the innovation of colored products. In addition, U.S. legislation describes not only the chemical molecule that corresponds to an INCI name but also its method of obtaining. Thus, natural mineral pigments are not authorized in the United States because the production process specifies that these pigments must be derived from synthesis.

USA Nom INCI	CEE Color Index	CHEMICAL NATURE	COLOUR
ULTRAMARINE BLUE	77007	$Na_7Al_6Si_6O_{24}S_3$ Alumina Silicate	Bleu Roy
CHROMIUM OXIDE	77288	Cr_2O_3 Anhydrous chromium oxide	Yellow green
CHROMIUM HYDROXIDE	77289	Cr_2O_3, H_2O Hydrated chromium oxide	Blue green
IRON OXIDE	77491	Fe_2O_3 Ferric oxide	Brick Red
	77492	Fe_2O_3, H_2O Ferric Oxide Hydrated	Ochre
	77499	(Faith$_3$or$_4$)$_X$, $(FeO)_Y$,$(Fe_2O_3)_Z$, H_2O Oxide Ferrosoferric	Black
PRUSSIAN BLUE	77510	$Fe_4[Fe(CN)_6]_3$ Ferric Ferrocyanide	Blue green
MANGANESE VIOLET	77742	$NH_4MnP_20_4$ Manganese or ammonium phosphate or pyrophosphate	Violet
TITANIUM DIOXIDE	77891	TiO_2 Titanium dioxide	White
ZINC OXIDE	77947	ZnO Zinc Oxide	White

Table 2. Classification of mineral pigments by Color Index increasing.

Sensory Analysis

MATERIELS & METHODS

There are many sensory analysis methods applicable to cosmetic products, which are summed up by Pensé-Lhéritier (Pensé-Lhéritier, 2015). At Chanel PB, the panel of experts consists of around 20 women trained to assess cosmetic products according to sensory, visual and texture criteria (Abidh *et al,* 2019). Protocols used for the different products presented hereunder:

- For mascaras, 20 exercised judges from the sensory panel participated in the construction of the sensory profile. The products are evaluated in comparison with the reference formula (Chanel's Inimitable). They are applied in a standard way at the rate of 10 + 10 passages of mascara. The definitions of the descriptors and the modus operandi were given to the panelists. Each descriptor is scored on a scale of 0 to 10.
- For foundations, 18 exercised judges from the sensory panel carried out the comparative sensory profile of the products. The definitions of the descriptors and the modus operandi were given to the panelists. Each descriptor is scored on a scale of 0 to 10.
- For eyeshadows, 19 exercised subjects from the sensory panel participated in the evaluation of eyeshadows. The product is applied in comparison of the reference eye shadow (Les 4 Ombres, shade 226 Tissé Rivoli), the products have not been tested in real comparison. The definitions of

the descriptors and the modus operandi were given to the panelists. Each descriptor is scored on a scale of 0 to 10.
- For all products, the data is collected and analyzed under the Fizz® software according to the statistical methods specific to profile tests: calculation of means and standard deviations, two factor analysis of variance (products, subject), Neuwman-Keuls 5% average comparison test and graphical representation.

RESULTS AND DISCUSSION

Impact of the percentage of mineral pigments in a mascara

In an H/E mascara colored with black iron oxides, the impact of pigment concentration on sensoriality is easily highlighted. The usual percentages of pigments in mascara formulas vary between 8 and 15%. Formulations were therefore made with respectively 8, 12 and 15% black iron oxide. The significantly different sensory criteria when increasing the percentage of black iron oxide are those relating to the makeup result, that is, the observations made after applying the product to the eyelashes. In general, the increase in pigments in mascara decreases the homogeneity of the deposit and the separation of the eyelashes, but increases the coverage, elongation and volumizing effect (tab.3). There is no impact of the percentage of pigments on the curling of eyelashes. There is a real influence of the variation in the percentage of pigments on the rheology of the boosting the volumizing effect by a higher concentration of iron oxides leads to an increase in the viscosity of mascara from its manufacture which makes the application more difficult. In addition, it causes a rapid and perceptible drying of the mascara over time which is harmful to the act of repurchase by the consumer. Also, if the promise of volume, an essential claim of mascara is well correlated with the percentage of pigment present in the formula, the induced drying effects must also be considered so as not to cause.

Analysis	8% pigments	12% pigments	15% pigments
HOMOGENEITY ON LASHES***	6.27	6.27	5.98
COVERAGE OF LASHES***	7.07	7.00	7.19
SEPARATION OF LASHES**	6.34	6.09	6.19
VOLUME OF LASHES***	5.45	5.68	5.85
LENGHT OF LASHES	6.97	7.15	7.22
CURLING OF LASHES ^{NS}	6.48	6.38	6.47

Table 3. Make-up results sensorial evaluation of 3 mascaras containing 8, 12 or 15% of pigments. Descriptors preceded by * are significantly different. NS : Non significative at 5% *:5% **:1% ***:0,1%.

Impact of the percentage of mineral pigments in eyeshadows

In two formulas of eyeshadow comprising identical pigments - iron oxides - but in triple concentration in one case, the increase in the pigment charge does not make it possible to differentiate the 2 compact powders to the touch (fig. 1). Only the makeup result is visibly different on certain sensory criteria. The eyeshadow that has the highest concentration of iron oxides deposits more product on application, gives a more opaque and intense result than the one with a lower concentration of pigments. It will logically be more visible on the eyelids and the differences are related to the difference in pigment concentration. Iron oxides have a good opacity related to a high refractive index, about 2.23, (Patnaïk, 2003; Lux, 1963) much higher than the refractive indices of other powdery charges present in an eyeshadow formula such as talc, mica which are rather between 1.53 and 1.6 (Bailey *et al*, 1965). Also, the more the proportion of iron oxide increases, the greater the opacity. Similarly, the density of iron oxides is about 5.70g / cm^3 while that of powdery fillers of the formula is rather between 2,60 and 2.80 g / cm^3 (Arib *et al.,* 2007). Also, the formula that contains three times more iron oxide makes a compact deposit on the eyelid while the one that contains the least gives an airier deposit. The deposition is therefore higher in the case of the formula that contains the most iron oxides.

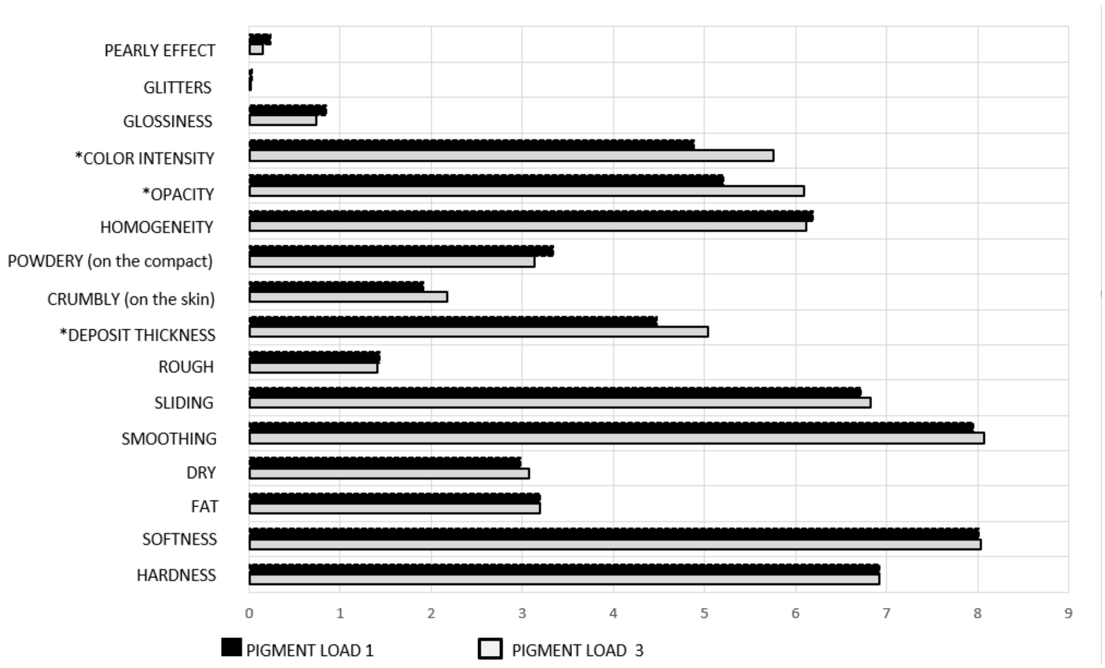

Figure 1. Comparison of sensoriality induced by pigment load in eye shadows. The descriptors preceded by * are significantly different. NS : Non significative at 5% *:5% **:1% ***:0,1%.

Impact of the nature of the pigments used in eyeshadows

Sensory analysis performed on eyeshadows formulated at a fixed rate of a mono pigment makes it possible to highlight the qualities and defects of each of these pigments. The four pigments compared in formulation are black iron oxide, brown iron oxide, ultramarine blue and cochineal carmine introduced at 9.8% in the eyeshadow (fig. 2). To the touch, brown iron oxide and cochineal carmine are the least soft. Cochineal carmine is the least fat, and the least smooth of all. We find the characteristic of the pure pigment which is rough, and which therefore brings this granular and dry sensation to the touch. Ultramarine blue is a pigment with a low color strength. Indeed, its refractive index is about 1.5, ranking it below the other mineral pigments evaluated (Nassau, 2001). Also, used in the same concentration as other pigments, it is the one that deposits the least product and that appears the most transparent in makeup result.

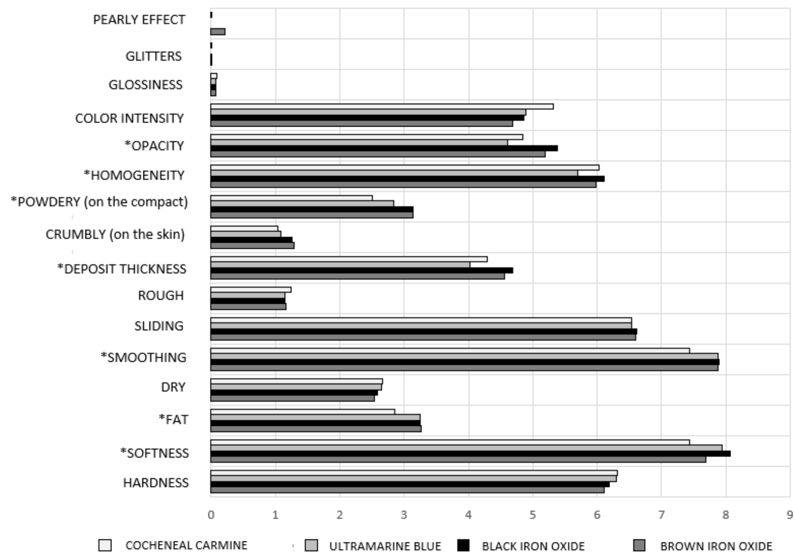

Figure 2. Impact of the nature of the pigment on the sensoriality of on eyeshadow. Descriptors preceded by * are significantly different. NS : Non significative at 5% *:5% **:1% ***:0,1%.

Impact of the ratio of mineral pigments in foundations

The offer of foundations is increasingly inclusive. On the same basis of formulation, the range can extend to 45 shades, from the lightest shade intended for Asia to the darkest one that meets the needs of the American continent. Regardless of the shade chosen by the customer, it is imperative that the entire range has the same sensoriality. A range of foundations that claims "fluidity and matity" must be of equivalent viscosity and matity from the very light shade to the darkest shade. Foundations are formulated with 4 pigments: titanium dioxide for opacity and clarity, yellow, red, and black iron oxides for hue. In industry, it is often more profitable to manufacture a fluid foundation firstly in four monochromatics, mixed in a second time with the right amount to obtain the desired shade. Also, four monochromatic foundations are manufactured in large quantities, each containing only one of the four pigments. Then, to achieve a defined shade, the four monochromatics are mixed in predetermined proportion to produce the wished shade. This makes it easy to realize the four shades of a range and to manage the corrections of shades in industrial. Four monochromatics of the same water-in-silicone foundation therefore have different sensory profiles. Also, when a wide range of shades is formulated from a mixture of 4 monochromatics, one of the difficulties is the harmonization of the sensoriality of the product within this range regardless of the shade. Light shades contain mainly titanium dioxide and dark shades contain little or no titanium dioxide but are concentrated in red and black iron oxides.

Colorimetric Values	**Clear**	**Dark**
L	75,41	56,78
a	9,9	12,57
b	18,55	22,19
C	21,03	25,2
h	61,92	60,47
Visual		
Pigment Composition %		
Titanium Dioxide	5,57	3,27
Yellow Iron Oxide	0,4	1,82
Red Iron Oxide	0,15	0,76
Black Iron Oxide	0,03	0,34

Table 4. Colorimetric datas of the clear and dark shades of foundations.

Figure 3 shows the sensory profile of 2 extreme shades, one very light and one very dark (tab.4): there is a very slight tinted impact only on the descriptor corresponding to the thickness at the application. The higher concentration of iron oxides promotes this sensation.

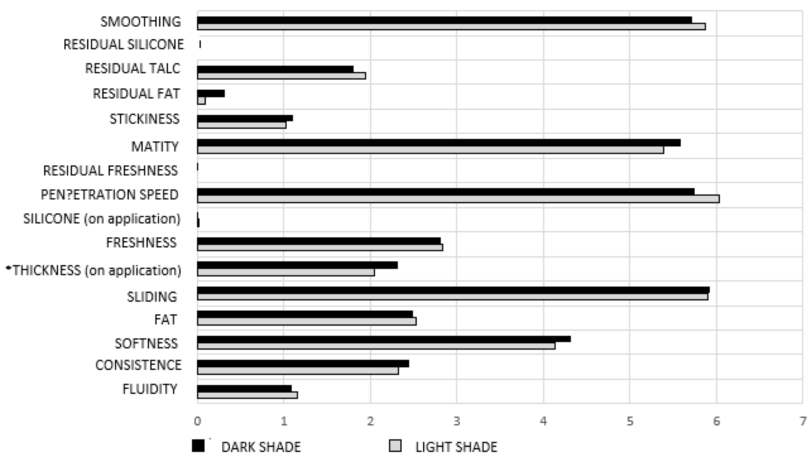

Figure 3. Sensory comparison of 2 foundations with extreme shades. Descriptors preceded by * are significantly different. NS : Non significative at 5% *:5% **:1% ***:0,1%.

Titanium dioxide is the most used mineral pigment in makeup until today. Currently questioned because most of these grades contain nanosized particles, it is still the only source of white in the profession. Indeed, of all white pigments, rutile titanium dioxide has the highest refractive index, at 2.75 (Blanchard, 2019). This is its major asset. The figure 3 shows, that the high percentage of titanium dioxide introduced into a light-colored foundation does not cause a significant sensory difference with a dark colored foundation. Thus, the influence of the variation in the ratio of different mineral pigments within a foundation is not a factor that leads to large tinted-dependent sensory variations. The coatings used to improve the hydrophobicity of pigments in water-in-silicone emulsions seem to play their role: the coating coats the pigment to facilitate its dispersion in the oily continuous phase emulsion. Here, a triethoxycaprylylsilane coating was selected for the formula. It makes it possible to optimize the stability over time, to promote the dispersion of pigments in the silicone medium but also to avoid the rise in hue of the pigments during the day if they are exposed to sebum or sweat. The coating thus applied all the pigments of the formula (iron oxides and titanium dioxide) reduces the physico-chemical differences of each of them. This homogeneity of behavior is therefore beneficial for the harmonization of the sensoriality of the shades within the range.

Conclusions

It is interesting to note that within the same family of pigments – mineral pigments – there are already significant sensory differences. Ultramarine blue does not have the same behavior as iron oxide or titanium dioxide. Similarly, yellow, red, and black iron oxides, of a very similar chemical nature, show some perceived differences in sensoriality as shown in eye shadows and foundations. These differences are also observed during the manufacture of cosmetic products. The most hydrophilic pigment such as yellow iron oxide, which is hydrated, is easy to grind. On the other hand, red iron oxide, dehydrated, is very difficult to grind and sometimes leaves unwanted red micro-dots in products. Black iron oxide is magnetic, and the vortex of industrial tools can lead to the appearance of black trails making the product heterogeneous in color and therefore non-compliant.

The color offer of a make-up range is very wide since it must address all skin tones, all customer's needs. Each of these pigments has a different composition, shape, particle size, hydrophobicity which will generate different behaviors in formulation. The role of formulators is to minimize the impact of colorimetric composition on the sensoriality of the finished product. The use of coated mineral pigments is one of the solutions applied to smooth the sensory differences between each mineral pigment.

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Assessment of base color influence on the chromatic appearance of hair colorants

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Abstract
Hair colorants of the so-called 'series of naturals', a scale of ten colors ranging from deep black to light blonde, are universally recognized as a reference basis for hair coloring procedures. However, it is frequently observed that application results are heavily dependent both in tone and in nuance on the underlying hair pigmentation. We hereby assess the chromatic appearance of a selection of globally marketed series of naturals, both on animal fur and on human dyed hair. Notably, the latter are chosen so to span a consistent range of melanin base, with a varying degree of interlaced depigmented strands. The analysis is carried out by means of a perceptual test based on the Munsell Book of Color, aimed at assessing the perceived tone and nuance with a special focus on the linearity of the scaling.

Keywords: hair coloring; cosmetic; color appearance; Munsell Book of Color.

Introduction

Judging the appearance of hair color is an essential task for proper salon service. Hair professionals routinely assess hair color at different stages of the coloring process including, but not limited to, once at the beginning, when hair current situation must be evaluated both in terms of tone and nuance; every time hair is rinsed from excess product; after a potential bleaching, by means of which hair basic tone is heavily lightened; after tonalization, a slight nuance correction usually employed to balance out residual and undesired undertones. These assessments leave little room for error, and in fact, customer satisfaction is reportedly low for a variety of technical reasons (Negretti, 2021).

Setting aside high-level human perceptual processing, color appearance is strictly dependent on a multitude of external factors. The artificial lightning of hair salons, for instance, is often designed around scenic impact, while its functional side leaves much to be desired. Not only are common LEDs spectral distributions unsuited to appropriate color evaluation, but their spatial placement is critical with respect to human vision. As an example, light bulbs framed behind mirrors may create glare, and directional lamps usually cast unwanted shadows over customers' heads and faces. Moreover, color blindness should be accounted for, ideally both in customers and in hair professionals (Fusari, 2021), and so should their ability to discriminate subtle color differences. Contrary to direct colors, which can be very easily told apart because of their brightness and saturation, more traditional (and vastly more requested) oxidizing products cannot. To name but an example, nuance 7.34 is golden copper blond, while 7.43 is copper golden blond: very similar to one another, yet slightly different in their predominant nuance. Finally, no actual standard exists in hair salon practice for proper color identification. A simple yet smart color naming scheme does in fact exist (Toninelli *et al.*, 2021), but its practical adoption is highly arbitrary among different color brands, so that hair color charts may very well associate different colors to the same nuance, both in terms of lightness and of predominant hue (Rizzi *et al.*, 2021).

In this paper, a method is described for assessing hair color that tries to compensate for all of these factors in a controlled environment. This method has already been detailed in (Toninelli *et al.*, 2021) for nylon swatches out of hair color charts, but this time, special emphasis is being put on the relevance of the effect of base color on the final appearance of hair colorants on actual hair samples.

Materials and methods

Three series comprised of ten hair swatches each were used for testing. Series number one (S_1) is composed of yak hair strands collected from Mongolian and Chinese animals, with next to no residual melanin, about 17cm long (of which 14cm available for coloring) and 1.4g heavy, clipped at one end by means of a plastic zip-tie (Fig. 1-left). Series number two (S_2) is a mixture of grey hair (80%) and white hair (20%), mimicking a situation frequently occurring on the heads of beauty salon customers (Fig. 1-middle). Finally, series number three (S_3) was originally comprised of ten chestnut brown swatches (tonal height 4.0, see below), on which a preliminary depigmentation was carried out by means of a 10-tones bleaching powder (21VENTUNO by Universal Beauty Products)(Fig. 1-right). In order to attain greater consistency, all swatches in S_3 were bleached at the same time by means of a mixture of the abovementioned powder and a 40-volume oxidizing agent (21VENTUNO by Universal Beauty Products) in a 1:2 ratio. Swatches were then wrapped in tinfoil and left in a stove at 30°C for 50 minutes. Excess product was washed away in lukewarm tap water, rinsed in ~1g of pH 5.5 shampoo (Post Color Back Bar Luxury), washed a second time and then coated in ~1g of a pH 4.5 hair conditioner (Post color Back Bar Luxury) in order to seal cuticles. Swatches were rinsed one last time, and finally blow-dried at about 160°C temperature.

Fig. 1 – Samples of the different swatches: yak hair (S_1 left); 80/20 mixture (S_2 middle); bleached 4.0 (S_3 right - original 4.0 can be seen at the top).

The series of naturals was chosen for application on these samples. Such series broadly classifies and arranges ten colors commonly occurring in human hair: '*Black*' (1.0), '*Deep Dark Chestnut Brown*' (2.0), '*Dark Chestnut Brown*' (3.0), '*Chestnut Brown*' (4.0), '*Light Chestnut Brown*' (5.0), '*Dark Blond*' (6.0), '*Blond*' (7.0), '*Light Blond*' (8.0), '*Very Light Blond*' (9.0), and '*Platinum Blond*' (10.0). In order to minimize inconsistencies, every color in the series was applied simultaneously to a single swatch out of S_1, S_2, and S_3. Thus, because no differences existed either in the mixture or in the application thereof, variations in color appearance could safely be ascribed to the base color alone.

The dyeing process was carried out in a controlled laboratory environment at 25°C, by mixing a 20-volume (21VENTUNO by Universal Beauty Products) developer in a 1:1.5 ratio. Colorants (Color Space Primary by Universal Beauty Products) were applied lengthwise on both surfaces and in both directions in order to achieve maximum penetration within the shafts—then wrapped in tinfoil and put inside a stove at 30°C. After 25min, swatches were removed from their encasing, washed in lukewarm tap water to remove excess product, rinsed in ~1g of pH 5.5 shampoo (see above), rinsed a second time and then coated in ~1g of a pH 4.5 hair conditioner (see above). Swatches were rinsed one last time, dried with a dabbing cloth and a hairdryer (160°C maximum temperature), all the while straightening and disentangling them with a round hairbrush and a fine-toothed comb. Finally, they were arranged in a horseshoe-like flat shape by tying loose ends together with a thin cord after a 180° folding about the midpoint (see again Fig. 1 for reference).

In order to evaluate the predisposition to differentiate between minute hue variations, all test takers were administered the Farnsworth-Munsell 100 Hue test before the actual perceptual experiment. In

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it, eighty-five colored caps[31] that span the entire range of Munsell Hues at both Munsell Value and Chroma 5 needs to be arranged along four black plastic rows. Test takers were instructed to rebuild the Hue series connecting the two anchored caps at both ends of each row, one cap at a time. The rebuilt order can easily be checked by turning caps upside down, for they are unequivocally numbered. The result (called Total Error Score, TSE in short) is an integer figure that accounts for positioning mistakes: the further apart two consecutive caps are placed, the greater the score.
Perceptual experiments were carried out inside a custom-made lightbox on whose inner ceiling two LED lamps were mounted and directed towards the core of the observation chamber. These sunlike LEDs by Toshiba are meant to cast a nominal 5000K light closely mimicking the ideal behavior a black body emitter, i.e.: the Sun. In order to better diffuse this light within the box, a frosted glass panel was securely fitted under the lamps, and inner walls were painted in uniform white. Illuminance measurements were acquired with a CL70F illuminance meter by Konica Minolta: luminance was 6900lx; correlated color temperature was 4880K; the visible spectrum is plotted in (Fig. 2).

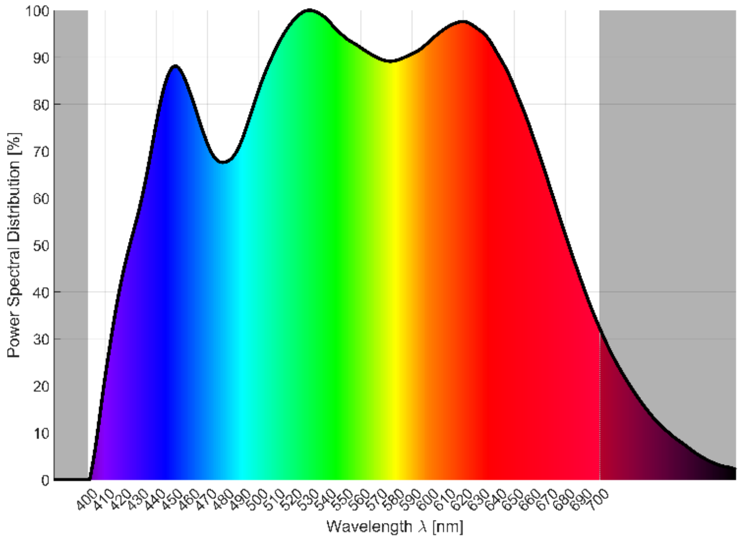

Fig. 2 – Illuminance spectrum of the Toshiba LEDs used in the custom-made lightbox (normalized by its peak value around 530nm).

At the core of the perceptual experiment lies The Munsell Book of Color, matte edition. Rather than providing the takers with entire Hue pages, a pre-emptive selection of colored chips was arranged for perceptual matching. Since each Hue page contains about thirty chips on average, providing two to three pages in order to guarantee a sufficient degree of variability with respect to Hue could have rapidly led to visual fatigue. Moreover, pages in the Book are consistently organized in an orderly fashion, with Values steadily increasing from bottom to top, Chromas from left to right. Such framing was feared to enable undesired patterns in the choice of chips. All this considered, fifty chips total were provided in order to encompass a sufficient variety of Hues, Values and Chromas. The final shortlist was agreed upon within the lightbox and arranged across two concentric circumferences on a white disc where slits were cut to accommodate the chips, and then numbered randomly from 1 to 50. An unbleached paper was chosen whose colour would closely match the one found on pages of the Book, which is inherently designed to be neutral[32]. On the 45°-sloped upper surface of a hollow wooden hemi prism a similar paper was affixed, and a metal peg was clasped in its center. The disc with Munsell chips was hooked on the peg, and then hair swatches on top of it, one at a time, so that the disc could be spun by takers to better match chips to swatches.

[31] Fifteen caps were removed by test creators themselves, hence the discrepancy with the original name.
[32] Common printing sheets are often treated with chemical bleachers to make them appear whiter. Collaterally, the treatment greatly boosts reflectance within the blue spectral bandwidth, altering visual perception of superimposed colors.

Visual matchings took place strictly inside the lightbox. The order of presentation of the swatches never followed the rightful sequence of the natural series. Instead, they were shown in steps of 3, i.e.: 1-4-7-10-2-5-8-3-6-9. This way, biases by virtue of reasoning were avoided, and actual perception was relied upon. Takers were instructed not to touch nor to remove neither swatches nor chips, and were only allowed to spin the disc. When a match was found, the test administrator recorded the corresponding number, and matched it to its Munsell nomenclature for further processing. Finally, test takers were asked a qualitative evaluation of test difficulty on a scale ranging from 1 to 5, namely: 1 - easy; 2 - somewhat easy; 3 - neither easy nor hard; 4 - somewhat hard; 5 - hard. An answer was requested after every match, but only for S_3, which was administered last. By that point takers were confident with the overall task, so judgements could be passed on the swatch matching alone.

Results

A total of 15 test takers was recruited, of whom six males and nine females, aged 21y to 40y. No subject suffered from any kind of medically certified or self-reported color anomaly or color blindness. The mean total error score (TES) of their Farnsworth-Munsell 100 Hue tests was ~17 ('*Average Discrimination*', yet very close to '*Superior Discrimination*'). Errors made had likely little to no influence on the perceptual performance. The Munsell Colour Solid accounts for a total of 100 Hues, but in fact only 40 of them are physically available in the most complete versions of the Book. Thus, all chips there contained—which were also those displayed in the matching test—are set two and a half Hue steps apart (100 divided by 40). The original Farnsworth-Munsell's test consisted of 100 caps, which were consequently set more or less 1 Hue step apart. Because the modern version of the test is comprised of 85 caps, these are set ~1.18 Hue steps apart (100 divided by 85)[33]. Therefore, a two-steps cap misplacement is required to approach the 2.5 Hue gap typical of painted chips. Since the greatest portion of misplacements in the test was made up of one-step swaps, test-takers were expected to tell Book chips apart confidently, at least as far as Hue was concerned. Furthermore, Hues involved in the actual perceptual test (mostly desaturated oranges and yellows) were all comprised within the less misjudged row.

Dealing with results of the perceptual test requires working on Munsell alphanumerical specifications, e.g.: 5GY 4/10. Values and Chromas are always numbers (respectively 4 and 10 as per the example), whereas Hues are composite of an arabic digits (5) followed by a short character tag (GY). The latter specifies Hue itself among a set of 10 total, of which 5 primaries (Red-Yellow-Green-Blue-Purple) and 5 secondaries (YR-GY-BG-PB-RP). The former provides instead a degree of membership to such label, with 5 being the center-most eponymous step, and the remaining 2.5, 7.5 and 10 stretching both sides towards adjoining Hues on the circle. Another nomenclature also exists coined by A.H. Munsell himself (the so-called *inner loop*), that orders Hues on a purely numerical basis starting from 1 at 1R and ending at 100 at 10RP. This decimal scale is precisely the naming convention that was used for Hue calculations.

Medians and interquartile ranges (IQR: 2nd to 3rd quantiles, or 25th to 75th percentiles) were chosen over mean and standard deviation. Data are discrete, because chips are as well, but not strictly ordinal: interval scales are known, and in fact Munsell color-order system is explicitly built on the premise of having adjacent Hues, Values, and Chromas scale uniformly with respect to human perception. There is no reason to believe the distribution to be normal, and in fact data contain a few outliers. As for symmetry, IQRs often show a distinct skewness (Fig. 3), which is useful for inferring a qualitative tendency of the data. For instance, Munsell Values for 80/20 swatches 5.0 and 6.0 are both 3, but the IQR of 5.0 is fully compressed onto the median, whereas 6.0 only has a non-zero third quartile. Therefore, 5.0 and 6.0 have about the same tonal height, but 6.0 could in fact appear slightly lighter. Median values are also shown for the difficulty evaluation task: the top row in Table 1 shows results relative to swatches, the bottom row relative to test takers.

[33] Supposing adjacent Hues were left equally spaced. Possibly however, chips were simply removed.

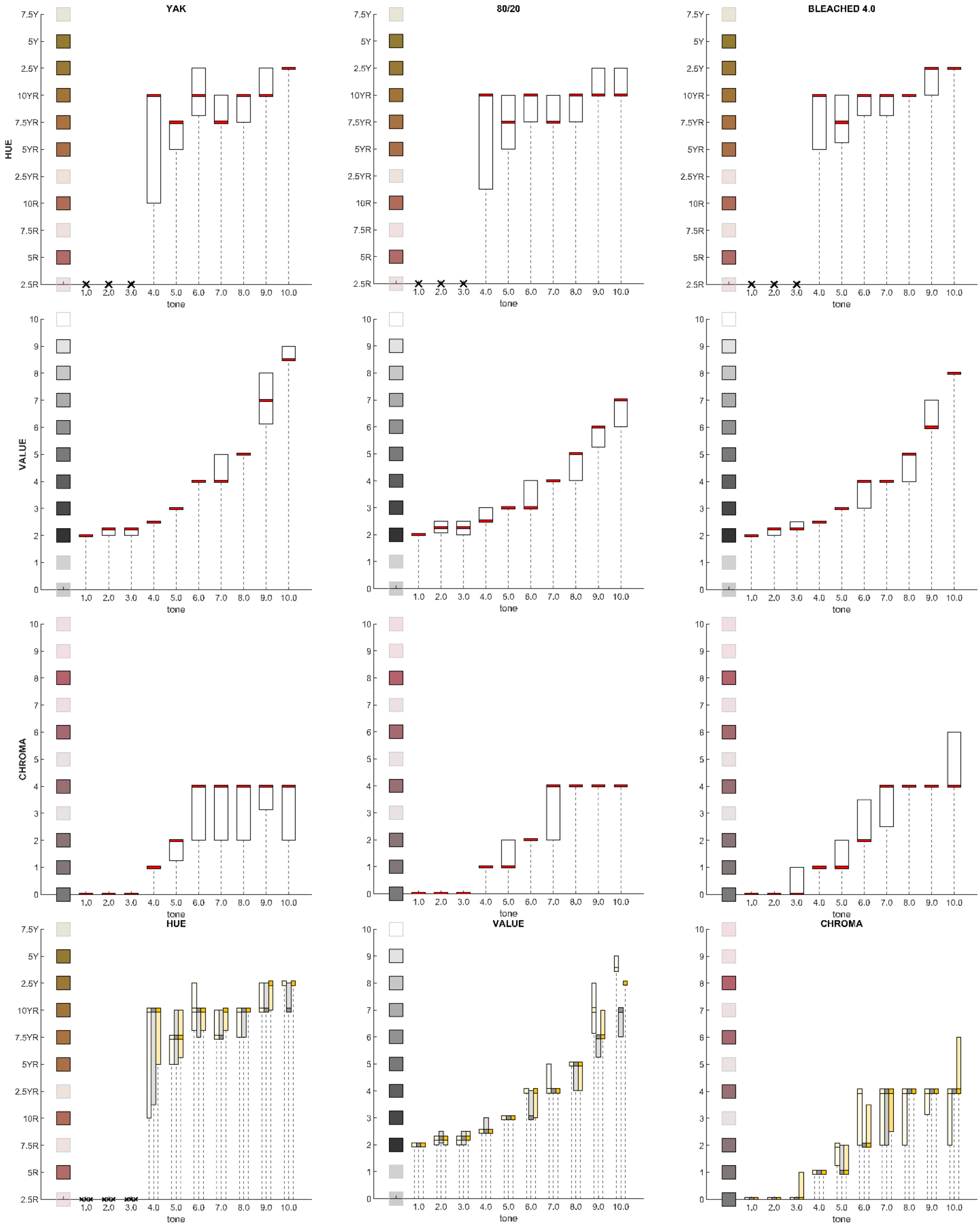

Fig. 3 – Results of the perceptual experiment. Munsell attributes are grouped row-wise, hair bases column-wise. The last row groups hair bases by attribute. Medians are marked in red or solid color squares; the second and third quartiles with white or slightly discolored vertical bars. Colored squares next to the y axis are approximations of Munsell chips. Colors are solid for attributes available in the chip selection, transparent otherwise.

1.0	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**					
2	2	3	2	3	3	3	2	2	3					
#01	**#02**	**#03**	**#04**	**#05**	**#06**	**#07**	**#08**	**#09**	**#10**	**#11**	**#12**	**#13**	**#14**	**#15**
4	1.5	2.5	2.5	3.5	2.5	2	2	2	3	3	2.5	3	2	2.5

Table 1. Qualitative evaluation of test difficulty (medians, 1 easiest-5 hardest), grouped per hair swatch (first row), and test subject (second row).

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Discussion

A method for the evaluation of dyed human hair color appearance has been described. Three different kinds of hair swatches were colored with the same series of naturals: yak hair; a mixture of 80% grey hair and 20% white hair; and finally, bleached brown hair. Observations were made under sunlike Toshiba LEDs by 15 takers previously tested for their ability to distinguish among colors. Results were reported in terms of the Munsell color-order system, which is widely employed worldwide for color appearance test, yet not for hair. We think, on the contrary, that its attributes Hue, Value and Chroma can be used for evaluating specific hair features such as, respectively, nuance, tone, and intensity (Liberini and Rizzi, 2022). The test has been generally well received: 10 out of 15 takers judged it overall easy (< 3), and the matching was considered somewhat easy for half the available swatches, neither easy nor hard otherwise, usually in this case due to a greater variety of undertones.

Contrary to common salon practice and color wheels depicted on hair color charts, where usually all tones of a given nuance are arbitrarily assigned a single hue (Rizzi *et al.*, 2021), Munsell Hue suggests differences along the series. As the Munsell Book of Color clearly outlines, the generic color ‘brown’ can refer to dark and desaturated versions of either red, orange, or yellow. Considering both median values and quartiles (Fig. 3, top row), hair browns (2.0 to 5.0) start in the orange region and slowly drift towards the yellow region, where blonds (6.0 to 10.0) are also identified. The transition is not smooth, partly due to swatch 6.0 appearing a little too yellow both on yak and on 80/20 in this particular color line. When compared on the basis of Hue, the three different hair types show small differences especially in the lighter swatches: assuming yak as a reference, the same 10.0 appears slightly less yellow once applied to the 80/20 mix, and conversely more yellow on bleached hair. This is likely due to swatch 10.0 shortcomings both in removing pre-existing melanin, and in covering up its residuals. In fact, it is easier and more reliable to cover fair hair in dark colors than the opposite, where bleaching is also required. For dark hair, on the other hand, judging Hue appears more prone to error, as the generally wider IQR bars clearly show. In this case, another misjudgment appears: very dark brown 2.0, and dark brown 3.0 were, on average, perceived as blacks. This shows through the combined reading of Hue and Chroma: the latter being 0 implies the absence of the former. The fact that this holds true for all tested hair types suggests on one hand a very good coverage of the underlying hair, yet on the other hand, that 2.0 and 3.0 should perhaps be better formulated in order to appear more chromatic. Swatch 1.0, i.e.: black, was correctly perceived as being achromatic.

The most striking feature regarding Value is its perceptual non-linearity. Ideally, should the series of naturals swatches be perfectly scaled at equal intervals, at least as far as human perception is involved, their Values would all fall along a straight line, reflecting Munsell Value linearity. Results suggest a quadratic distribution, where browns are much closer to one another than blonds are. Value is also the attribute which highlights base color effects the most. The endpoint for yak, the most neutral base, is 8.5; it is slightly lower at 8 for bleached brown; and conspicuously lower at 7 for the 80/20 mix. Again, this is due to the fact that lighter blonds have far less impact on the underlying hair color. Because of this, and contrary to Hue, a generally greater variation in Value assessment is attained in the blond half of the series, where residual natural pigment is removed more erratically than intended.

Any comment on Chroma is somewhat slightly marred by the intrinsic limitations of the Book, where this attribute is shown on colored chips in increments of 2. Also, chromatic swatches of the series of naturals, i.e.: those from 2.0 upwards, very rarely rise above Chroma 4. All these things considered, the useful Chroma range appears rather undersampled. Unfortunately, the Nearly Neutral Munsell collection in our possession, on which Chroma increases in half steps, is in turn undersampled with respect to Hue, and available for Values 6 to 9 which are only really useful for swatches 9.0 and 10.0. Having said that, after a relative peak around swatch 7.0, Chroma decreases slightly for yak; it remains constant for 80/20; and it slopes up for bleached brown, possibly due to the visible residual chromaticity of the base. In any case, lighter swatches are always more chromatic than darker ones.

Conclusions

Hair coloring is a very delicate matter (Voss and Wong, 2021). Marketwise, no two color lines exists whose colors are actually the same, despite having equal names. Moreover, each head of hair bears differences, either subtle or apparent. For instance, the great variety of base colors must be considered by hair professionals before any coloring treatment is applied. This paper has shown how different color bases influence the overall color appearance of the series of naturals, highlighting changes both in tonal values and perceived nuance to a lesser extent, especially when lighter tones are considered.

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Hair-dye experience at home using a customer journey map

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Abstract
The hair-dye market is growing rapidly. Due to Covid-19 and the boom of personal care in the beauty industry, dyeing hair at home became a fashion led by young females. This study observed customer experience while using at-home hair-dye kits through video observation and in-depth interviews. Adapting the user journey map, we tried to diagnose the pain points of the current hair-dye experience at home. As a result, we prototyped the package and screens of the digital service. It is meaningful that this study designed a new customer experience at home, by applying video ethnography and a user journey map.

Keywords: Hair Dye, Customer Journey Map, Meta-Verse, Package Design, At-home

Introduction

COVID-19 has accelerated the way we work and our lifestyle. As People are encouraged to stay indoors or wear masks, industries started to seriously take into account the customers' indoor activity experience. which is called at home in many services. The beauty industry is no exception. In the cosmetics domain, the fundamental desire seems to be the rise of overall interest in indoor personal care experience. Hair dyeing has been considered an authentic service provided by professionals in beauty salons. However, the trend is changing now (NBC news, 2015). L'Oreal group, which is one of the most prominent companies in the world, reported that a business segment of the haircare market exceeded 22% of the world and became the second-largest segment after the Skincare market(L'Oréal Group 2021). They also announced that in the haircare market, the growth of the hair color product line is especially remarkable. The growth of the hair care market is a major change in the beauty industry due to COVID-19. As described, the hair cosmetic industry is growing rapidly and, thereby, the self-hair-dyeing product lines took a spotlight in the beauty market.

Until now, studies related to hair dye were mainly about its chemical features. Researchers in the chemistry field or biology field dealt with hair-dye products, to improve their performance and safety. They focused on focusing on reducing the chemical toxicity of hair dye, thereby reducing hair damage, and its negative effects on health (Kashetsky et al. 2021; Kim et al. 2016; Morel et al. 2011). While companies are anticipated to investigate qualitative aspects of customer experience to enhance product competitiveness, only a few studies have focused solely on customer experience. Choe conducted a study on the customer experience of hair dyeing at the salon, reviewing the view of hair professionals(Sharad 2018; Madnani 2013). The previous studies lack studies on ordinary customers' experiences, especially on self-hair-dye product users.

There are various research methods to collect insights from ordinary customers and their experiences. Considering the context surrounding them and the purpose of research, methods such as design ethnography, co-design workshop, persona are often adopted (Atkinson, 2007). Design

ethnography allows researchers to empathize with the objects of observation, providing a further understanding than a simple collection of data. Video ethnography, a special type of design ethnography, utilizes video to collect data and is meaningful when user experience takes place in special spaces, like their home (Hanington, 2003). The collected user data are used to create insights. After that, designer and design researchers visualize these data through a user journey map, a graphical method that can enhance an understanding of each process of customer experience. Rosenbaum said that a well-made, and realistic customer journey map can foster innovations (Rosenbaum 2017). User journey map also allows researchers to look through the experience holistically and qualitatively, especially focusing on realistic difficulties customers are facing (Hanington et al. 2019).
We adopted both video ethnography and a user journey map to understand customers' hair-dye experience at home. Video ethnography was conducted based on popular youtube videos regarding at-home hair dye. These days younger generations lead a trend of 'personalized',’self-expressive,' inclusive', or ‘diverse' beauty experiences, unlike the passive nature of those in the past (Vogue Business, 2021). This trend relates to the enthusiastic use of social media, as many people are eager to share their own experiences with others. Thus, we utilized Youtube videos as our source of customer observation, believing that they would contain a very authentic experience. Then, we employed a user journey map to organize the observations, analyze the challenges, and derive potential services or products. The design method facilitated the investigation and problem-solving process. We attempted to address customers' needs and then propose solutions to resolve the potential demand. Through this research process, we tried to explore the holistic customer experience while covering both technical aspects and qualitative experience to properly pinpoint the customer desires.

Method

Video Ethnography

We reviewed 63 Youtube videos about an at-home hair dye experience with high view counts and relevancy. In this study, we focused on the “Hello-Bubble” hair-dye products from the Mise-en-scene , a brand of Amore Pacific Inc, a leading beauty company in South Korea, well known as “K-beauty”.That certain product was the most frequently used in previewed 63 videos. 8 youtube creators were selected among them, to be observed more carefully. The creators were from various countries, hair types, or hair colors.

Interview

After the video observations, we recruited four interviewees(all females, Mean age= 24) who were familiar with at-home hair dye and asked them about their own experiences in detail. We asked them why and how they chose certain products, their personal color preferences, and their major dissatisfaction during the at-home dye experience.

Customer Journey Map

This study adopted a user-journey map method to investigate the current user experience of at-home hair dye. To visualize self hair coloring process at home and to analyze pain points through interviews, we structured the journey map into three user states ; A searching phase, dyeing phase, and post-dyeing phase. After labeling each state, we visualized our suggestions regarding the new system including physical and digital approaches.

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Results

Based on the observation and interview results, we created a customer journey map including both the status quo and the new experience as solutions. For further explanation, we divided the journey map into three parts. First, we analyzed the current customer journey in part A (Figure 1). This part visualizes and explains customer actions, emotions, and desires of current customers. Then, in part B (Figure 2), we arranged the relationship between the status quo and the new solution, explaining how the pain points can be solved through physical and digital approaches. Lastly, in part C (Figure 3), the new customer journey itself is introduced. The whole view of the journey map is shown in Figure 4.

Part A. Current customer journey while dyeing hair at home

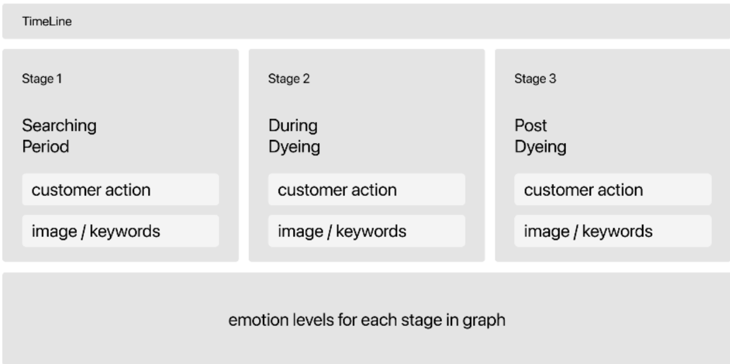

Figure 1: timeline, customer action, image, keywords, and emotion of the current journey

Figure 1 shows the current journey of customers when they dye their hair at home. Each step in the timeline can be examined. In stage 1, the searching period, customers look for necessary information as preparation before actual dyeing. They search for the best hair-dye color that would suit their style, mostly based on the concept of personal color. Brand reputation and product convenience were also important when selecting a specific product. In this stage, they are full of anticipation, imagining the different look they would have after dyeing their hair.

Stage 2, ‘during dyeing’, consists actual dyeing process. Due to the unpredictable nature of hair dyeing, most customers feel nervous and scared. They said that other people’s reviews are not helpful at all since hair-dye color resudifferfers so much by individual hair characteristics, even if they use the same product. At this point, the only information customers can rely on is the official information provided by the companies of the product they are using. Customers pointed out that there was too little realistic color information. They felt tired of photoshop-ed images of celebrities printed on the package since it is never similar to realistic results. Plus, they said the before-after color information is too simplified to get actual help in predicting their hair-dye color result.

In stage 3, the post-dye period, customers check their dye results and try various hairstyles with a new color. Although many of them face different color results compared to their expectation, it is interesting that they feel happy rather than disappointed. Since the whole process is DIY, customers feel proud of it after all. Interviewees said that the unexpected, and rather random outcomes are sometimes fun because it feels like they are playing a game. Plus, all the interviewees mentioned that they visit malls to buy products that would match their new hairstyle. They love this process and have a desire to keep a record of their new look.

Part B. A design direction to enhance the current journey

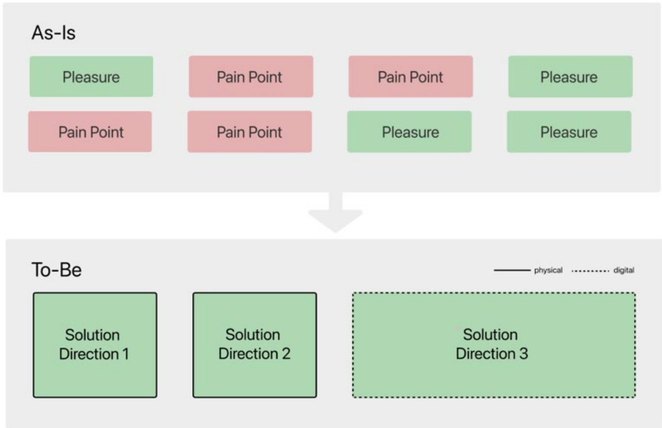

Figure 2: A design direction of a new journey, visualized in As-Is / To-Be diagram

We found that people are afraid of unpredictable results in the status quo. Customers were frustrated by unrealistic color information, that doesn't apply to their circumstances. But at the same time, customers also enjoyed that certain unpredictability, as if the dyeing process were an exciting game. We sought this situation as a breakthrough to new opportunities. To give a better experience to customers, we can minimize the frustrations through a physical approach, while maximizing excitement through the digital approach. As a physical system, we suggest a new package design that can technically solve the inconveniences. For the digital system, we suggest a digital service that could enhance the overall joy of the whole process through new entertaining content.

Part C. A new journey: A color-diagnosis package and a digital diary service

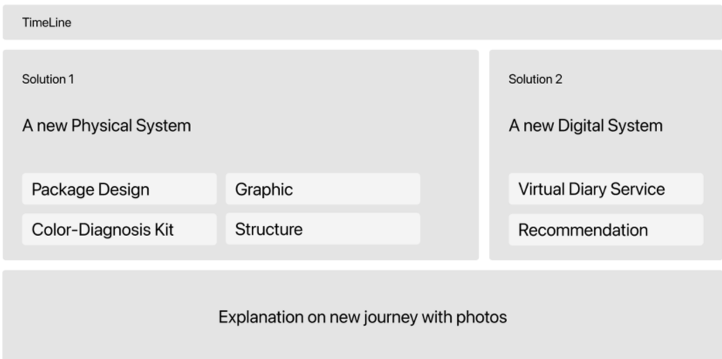

Figure 3: Details of the new customer journey including package and service design

Interviewees said that the packages of existing home hair dye kits significantly lack detailed color information. Although the packages are full of fancy, alluring images, they fail to communicate with a wide range of customers since they lack diversity when showing the outcome colors. We designed a package that focuses solely on communicating color information. The graphic of the new package has a more universal and inclusive feel without fancy celebrity photos. This design allows customers to have a more color-focused experience. The new package also introduces a system that enables customers to check their current hair color status, and get an idea of the result color. This new system, "9 level Color System" is applied both in package graphics and structure. The gradient in the front expresses the dye result of 9 different colors of virgin hair. This graphic is structurally connected to the top part of the package, which becomes a 9-level color stick and a

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written guide when torn off. This system provides two primary information, natural hair color, and the average dye outcome, in 9 levels of a brightness scale. The system is visualized into a simple form of a stick, which is carefully crafted in to package structure. As shown in a series of pictures in figure 3, customers can simply tear off the stick from the package, diagnose their hair color before dyeing, check the predicted result, and refer to the written color guide to dye their hair into a tone they prefer.
We also suggest a concept of digital service to maximize the entertaining aspect of the current at-home hair dye process. By connecting a mobile service with a new package through a QR code, customers can enter a digital playground. This space provides them a new entertaining content that helps them with the after-care process. These contents include a 'virtual diary service' which helps customers cherish their moments with new hairstyles. The virtual avatar reflects the style change, and the avatar itself becomes a style record for each customer. This service takes the advantage of recently popular meta-verse technology, helping customers to focus more on themselves. Furthermore, digital space can be used to give shopping advice, providing recommendations for various products.

Discussion

First, we would like to mention that we adopted the video ethnography method, especially with YouTube videos, to investigate users' hair dyeing experience at home. What should be noted in the video ethnography is the objectivity of the video: this study is based on YouTube videos and paid particular attention to whether the target video contains the YouTuber's unrefined self-dyeing process, including subconscious intention or emotional expression. Due to the context of self-dyeing activity and the nature of one-person broadcasting, we judged that the chronicle activity of using hair dye was vividly recorded. In addition, an interview method was added to supplement the observation of ethnography. We conducted YouTube video analysis and interviews to investigate hair coloring experience at home.
In addition, in the aspect of customer experience, we found that there is a distinct difference between the dyeing experience at the salon and the self-dyeing experience. The essence of the customer experience that we found in self-dyeing at home was whether the color of the dyeing result, that is, the desired color, came out or not. This desired color means a predictable color to customers or a color that suits them well within the acceptable color spectrum to some extent, even if they did not expect the distinct color. Considering previous studies that the main issue of customer experience at salons was about safety, such as hair damage and scalp stinging, we found that the customer's need for the color area was strengthened more than ever.
Lastly, considering the Millennial's propensity is needed. Since the millennials are familiar with expressing their emotion through SNS and keep recording their new look, we proposed new digital content for entertaining aspects, such as the mobile service with QR code and the virtual diary service. Validation of the solution requires further user study as future work. Also, whether the proposal can actually be adopted by a company may reflect more practical problems such as unit cost of production or stakeholder issues.

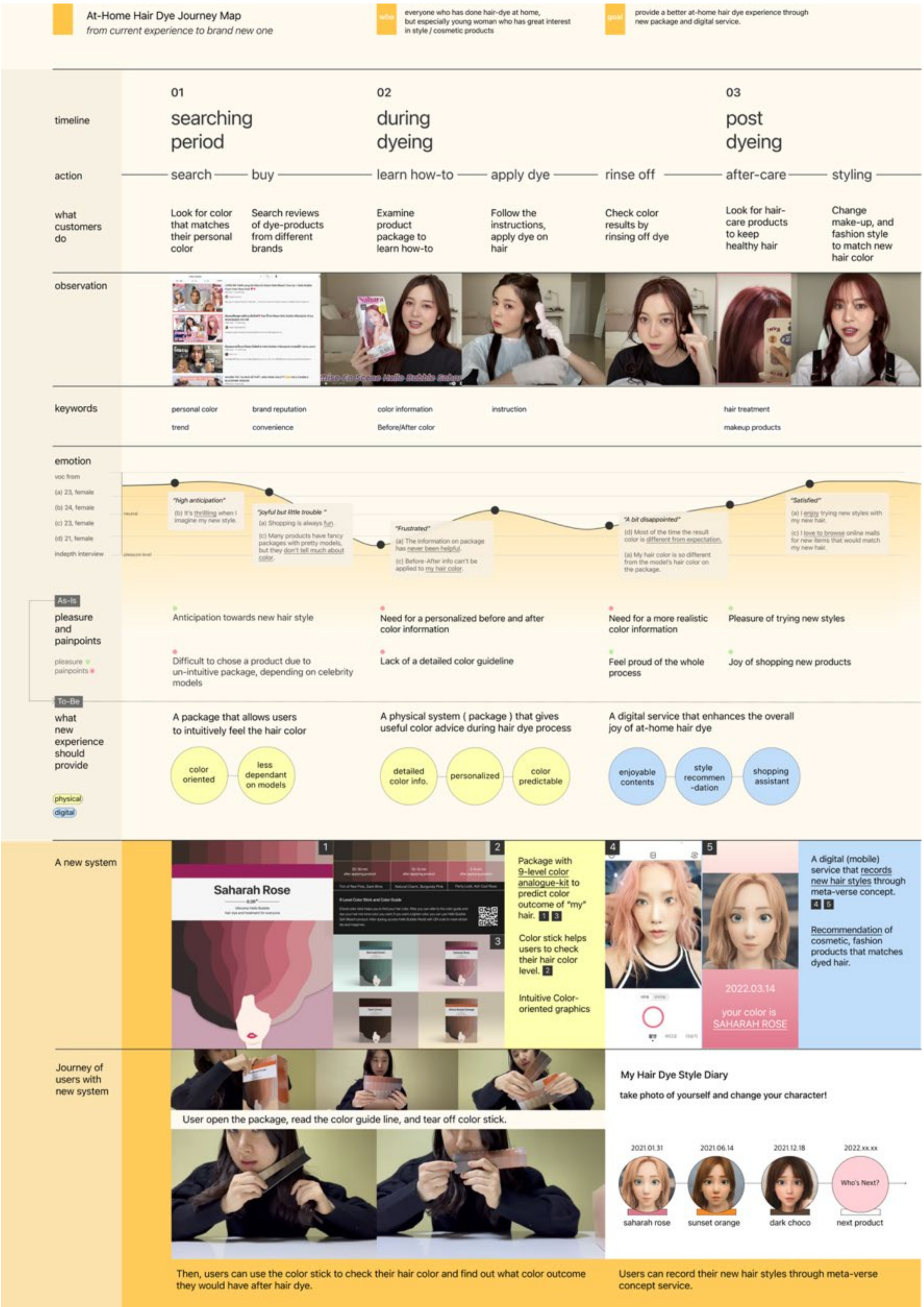

Figure 4: customer journey map in the whole view, the journey of hair-dyeing at home

Conclusion

In this paper, we adopted two design methods to explore the customers' hair coloring experience at home. Video ethnography was utilized to investigate Millennial's holistic hair coloring activity and in-depth interview was used to understand their motivation and emotional aspects while hair-dyeing activity. We created user journey map to visualized the collected data and pain points through interviews and to enhance the understanding of each process of customer experience. Through this process, we proposed the new customer experience. To serve this solution, digital services are devised and new hair-dye packages are designed to support the new experience. This study presents a more personalized and entertaining at-home hair-dye experience by systematically exploring the process, focusing on customer pains and desires.

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The color changes of face after a makeup for Shanghai Women

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Abstract
This study proposes color analysis to examine the color changes of face skin after the makeup. Participants were photographed before and after the skin makeup. 516 Chinese females in Shanghai were participated. We proceeded color calibration for the collected images and extracted the pixel colors of cheek regions in L*, a*, and b* value. The results showed that the facial colors of the Chinese females became brighter, less reddish, and less yellowish after the makeup, thereby resulting in a paler skin undertone.

Keywords*:* Facial skin color, Chinese females, Skin makeup, Liquid foundation

Introduction

As awareness of skin color diversity has been raised and internationalization of beauty industry has been accelerated, the cosmetic industry increased their available shade color options to meet customers' needs. Especially, famous global brands such as Lancome and Mac played a leading role [1] in the early stages of the era. As a result, holding a broad range of shade colors has become a familiar concept for cosmetic brands [2].

In fact, preferred skin tone could be different from the actual skin tone, as Bartleson [3] revealed that the real skin color could differ from memory color. Zhu et al. [4] addressed that memory skin color is affected by visual environment condition, which is well known in previous study, but also cultural background. Yamamoto et al. [5] studied how preferred skin color is different for three East Asia countries. According to Yamamoto, there is a significant difference in accepted skin between three nationalities and Chinese preferred the brightest skin color, 78.12 as L* value. They revealed that the preferred skin colour is determined not only by the memory-colour of skin but also by cultural factors. However, even after this study, researchers has not been distinguished the subtle cultural difference [6].

Compare to other mature cosmetic markets such as US and Japan, China's cosmetics industry still has room for growth [7]. As we described, though the concept of personal color has been raised, much research related to wanna be skin tone has been conducted and its adoption in practice was rarely addressed. Study on putting makeup into practice to trace preferred skin color change is still unexplored. In this circumstance, this study investigated the color distribution of Chinese females by comparing their bare face with skin makeup faces.

METHOD

Subjects

A total of 516 Chinese females were recruited among employees of Cosmax China in Shanghai. All were volunteers and paid for the participation. Their average age was 30.15 years old with a standard deviation of 4.40 years.

For the Shanghai dataset, the Canon's EOS M50 camera was used throughout the experiment and set with ISO 200, aperture size F/5.6, shutter speed 1/13 second, the white balance to Auto White Balance(AWB). The photos were archived in both RAW(*.CR3) and compressed format(*.jpg), and the data were transferred to a cloud server, Baidu. All pictures were taken in one laboratory with fixed light conditions.

18-inch ring-shaped light

To generate a uniform light condition, we used an upright ring light with a diameter of 18 inches. The correlated color temperature was set as 5,600 [K], and the CRI was above 90. The ring light was installed vertically, and the height was adjustable to the sitting height of the individual participant. The distance between the subject and the light was fixed at 1.0 meters. As the ring-shaped light had a camera holder in the center, so was the distance between the camera and subject was maintained at 1.0 meters, too.

Protocols and Procedure

The study protocol began with a selection of a shade. Subjects chose the best matching shade among the five liquid foundations and applied it to their facial skin. After taking a photograph, we asked the subjects to remove their makeup and answer the survey. The survey took around 10 minutes. The survey intends to collect subjects' demographic data and makeup behavior. The questionnaires included age, makeup frequency, problems with facial skin, and perceptual qualities of both current and ideal face colors. Lastly, we took another photograph of the subjects' bare skin.

The algorithm to extract facial colors

Initially, we calibrated the pictures using the software provided by x-rite. However, the calibration procedure referred to the entire color patches as the references, thereby resulting in substantial errors, when we focused on the skin color patches. To best fit our research purpose, we developed an algorithm that calibrated the image and then identified the individual's facial landmarks. To perform the calibration focusing on skin color correction, we deliberately focused on the skin color set among the reference color patches. In order to identify sub-regions in each photo, we used the EOS library that applies the Surrey Face Model (SFM [8] mesh vertex indices based on the 68 ibug annotations [9]. The SFM mesh vertex included 845-point annotations, and the EOS library interpolated up to 3448-point annotations. Then we adopted the vertex-based subsets of facial regions introduced in a previous study [10, 11]. Finally, we estimated the median values of L*, a*, and b* from the subset regions. By doing so, we managed to identify the color values of the forehead, upper cheeks, lower cheeks, nose tip, and chin from the facial images. Python was used to perform the algorithm.

Evaluation of facial skin makeup

After we collected the facial pictures, we conveyed an evaluation session. Seven makeup experts joined an online evaluation in that participants' facial pictures were presented as a pair: one with a bare face and the other with face makeup. The seven experts went through the picture array while giving scores ranging between -1(poor makeup) and +1(successful makeup). Based on the evaluation scores, we intended to group the participants for comparative analysis.

RESULT AND ANALYSIS

The algorithm resulted in the L, a, and b values of representative facial regions. Based on the values, we identified the color distribution of all participants. In particular, we paid attention to that how the color has changed after the facial makeup. Also, only a minority group of Chinese females put on makeup almost daily, and thus we tried to select frequent cosmetic users from the entire participants. Moreover, by combining the evaluation scores, we attempted to figure out the makeup behaviors of highly involved cosmetic users.

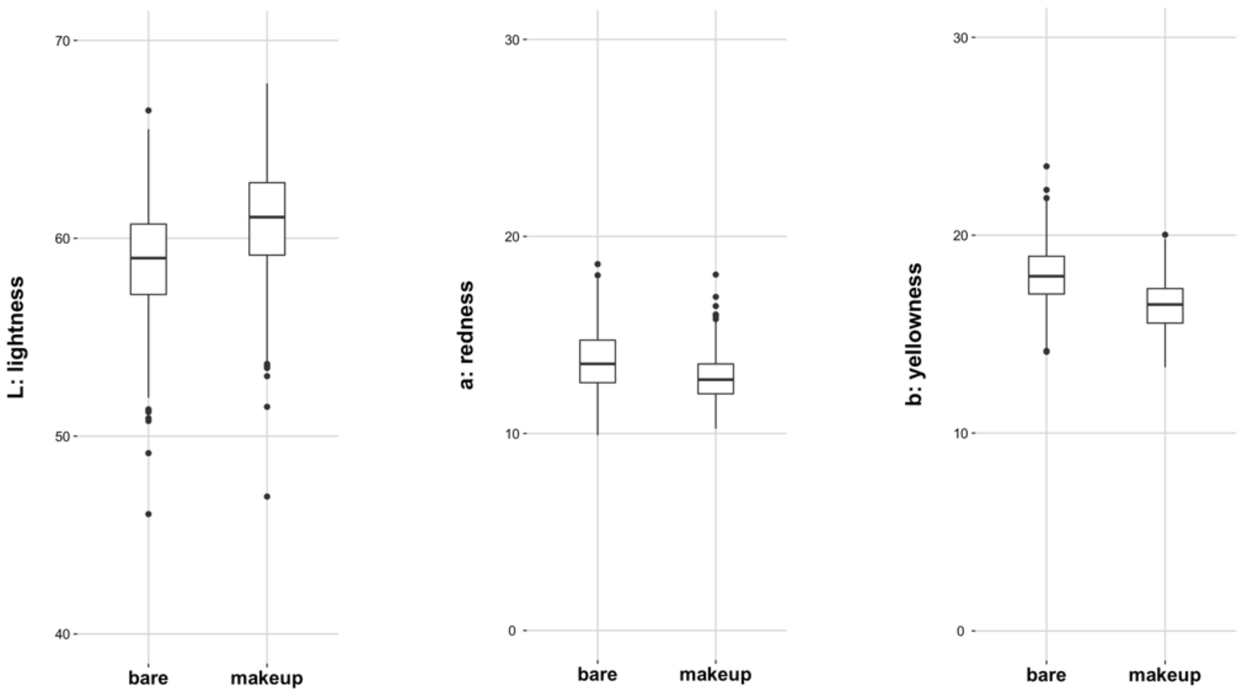

Figure 1: The central tendencies of facial skin colors in aspects of L, a, and b values. The box plots are comparatively displayed demonstrating the color shift after the makeup. The color values were extracted from the cheek regions. (N = 516)

Descriptive statistics

Facial skin color distributions

According to Yamamoto [7], the preferred facial skin color was estimated as L* = 78.12, a* = 16.40, b* = 13.74, although the measuring approach was somewhat different from ours. The algorithm resulted in a set of color values of individual facial images. Figure 1 displays how the facial color values were estimated, and the distributions are compared between the bare and makeup skins. The central tendency of distribution patterns indicates that the facial skin color became lighter, less reddish, and less yellowish. The mean changes were + 1.91(L*), -0.87(a*), and -1.50(b*), respectively, and the mean differences were statistically significant at an alpha level of 0.01 yielded by pairwise-samples t-tests (N = 516).

Color relationship between bare face and the chosen liquid foundation

The five foundation products were labeled in their own color system by the brand. To quantify the differences in an objective manner, we arranged them in order of brightness(L), redness(a), and yellowness(b). However, differently from our anticipation, the order of foundation products did not appear to be related to the L, a, or b values of the bare skin colors. For example, we expected participants with brighter skin might have chosen the brightest foundation for a natural-looking. As shown in Figure 2, the averaged L value of the participants' cheeks who chose the brightest foundation 1C0, was not noticeably different from L value of other participants' cheeks. The central tendency of color changes did not seem to be aligned with the color values of the foundations. Instead, we obtained the insight that individuals had different anticipations about changing their facial skin color rather than conforming to a

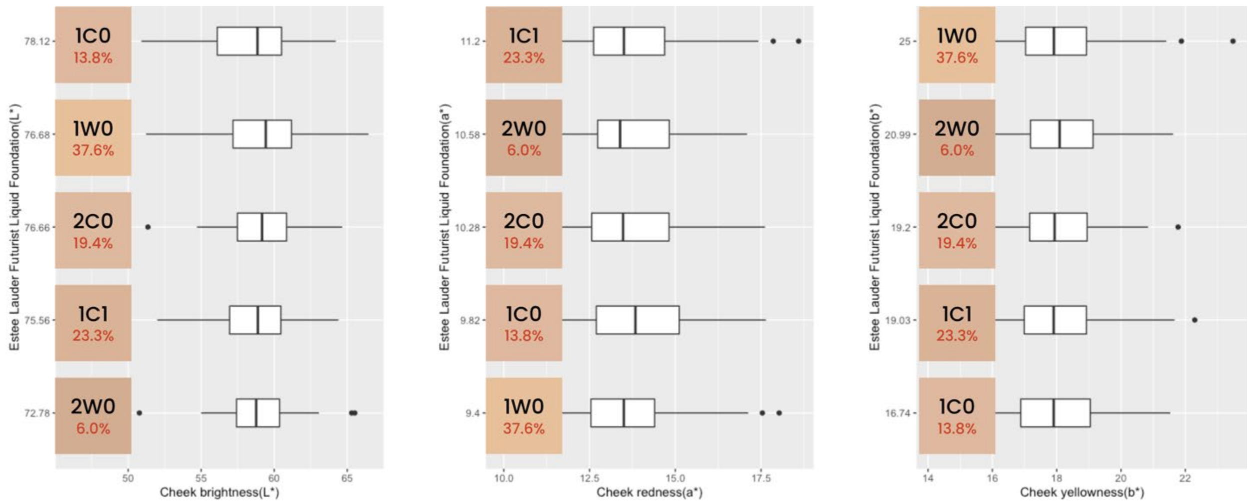

Figure 2: Arrays of five liquid foundations in order of L, a, and b. The overlapping box plots are the distribution of the participants' facial skin color. (N = 516)

fixed convention. Alternatively, participants selected the foundation based on the products' visual appeal rather than the match between their facial skin color.

Characteristics of frequent cosmetic users

Based on the survey responses, we tried to identify the frequent cosmetic users who put on makeup almost daily. According to the survey question, "how often do you put on makeup?", we provided three options- "almost daily (173 subjects out of 516)", "occasionally(204/516)", and "rarely(126/516)", which indicated that makeup is not perceived as mandatory to go for work. All participants were employees of the cosmetic company, however, makeup is not a daily routine of the majority.

Furthermore, among the 173 subjects who put on daily makeup, we selected 55 subjects whose makeup evaluation scores were higher than 5 out of 7 judged by seven cosmetic experts (score range: -7 ~ +7). We considered those subjects were the "fashion people" with a higher engagement with cosmetics and makeup. Interestingly, the fashion people chose 2C0 the most(43.6 %), differently from the majority of subjects as compared in Table 1. The fashion people tended to choose the pink-based undertone, namely, "cool tone", more than the rest of the subjects.

Since the fashion people showed a preference tendency for the 1C1 shade, we anticipated the fashion people's makeup faces to be more reddish. However, when the independent samples t-test was performed to compare the L, a, and b values between fashion and non-fashion people, the statistics failed to find any statistically significant difference not only with bare faces but also with makeup faces ($p > .05$). We concluded that across the two groups, their facial color became paler, i.e. lighter, less reddish, and less yellowish.

Table 1: The foundation choices of 55 fashion people compared with the entire 516 subjects.

Color code	516 subjects	55 fashion people
1W0	194 (37.6%)	9 (16.3%)
1C1	120 (23.3%)	13 (23.6%)
2C0	100 (19.4%)	24 (43.6%)
1C0	71 (13.8%)	8 (14.5%)
2W0	31 (6%)	1 (1.8%)

DISCUSSION

Major findings

The entire subjects were photographed in a controlled environment. Nonetheless, when we performed the calibration algorithm based on the skin patches of the Color Checker Passport, precise adjustments were necessary to make corrections of skin color. This indicates the challenges in skin color calibration. Based on the calibrated facial photos, we extracted and averaged color values in terms of L, a, and b focusing on the cheek regions on both left and right cheeks. As displayed in Figure 1, the facial colors became brighter, less reddish, and less yellowish, namely paler.

Because we provided five kinds of liquid foundations, we hypothesized that subjects' skin characteristics would influence their choices of foundations. However, as illustrated in Figure 2, we failed to find any relationship between skin color and foundation color. In the Figure, the five foundations are arrayed according to the increase of L, a, and b in each chart. However, the facial color of the subjects who chose the foundation does not show any increasing or decreasing trend. This implies that subjects selected the foundations as they liked, which was not aligned with the color characteristics of their facial skin.

CONCLUSION

This study proposes a method to capture and analyze facial skin color, especially by comparing the color of before and after the makeup. We developed a procedure that includes collection, calibration, and extraction of the facial colors in CIE1976L*a*b* color system. A total of 516 young women participated in Shanghai, China. Based on the facial photos, we figured out the color changes, especially after having divided the subjects according to shade choices as well as makeup characteristics. The color tendency after the makeup was consistent, and the faces became paler- brighter, less reddish, and less yellowish. The trend was applied to entire subjects, and was not related to makeup frequency nor skills. Moreover, the facial skin color was unrelated with the choice of liquid foundations, differently from anticipation.

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Course of Color Technician in the Cosmetic Industry

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Abstract

In order to meet the requirements of the enterprises among the cosmetic and wellness industries, for which the training of specialised experts in the knowledge of color is a crucial need, Poliestetico di Milano has devised, in collaboration with a group of important partners, a course of HIGHER TECHNICAL EDUCATION AND TRAINING, aimed at creating a "new" specialised technical profile as COLOR TECHNICIAN IN THE COSMETIC INDUSTRY. The course will take a total of 1000 hours to be completed, of which 500 hours will be for lectures and laboratory plus 500 hours of training in the company.

The project has been developed in agreement with the IT department of the University of Milan, represented by Professor Rizzi, Universal beauty Products and also involves two important secondary education institutions within the chemical field, such as the Hensemberger Institute of Monza and the Molinari of Milan. This article presents the course description of this new professional program developed by Poliestetico di Milano. This IFTS (HIGHER TECHNICAL EDUCATION AND TRAINING) course of Color Specialist, has been approved and financed by the Lombardy Region, aims to fill the lack of advanced education and training in the Beauty Industry.

Keywords: Beauty, Color education.

Introduction

The path of Color Technician arises from two main needs found among companies producing cosmetics, specially in the Lombardy region, and companies selling cosmetic products, hairdressing and beauty services.

For cosmetic production companies, it is urgent to include professional figures specialised in color scientific knowledge, who can help in solving the various critical issues that emerge from the different color products assessment between manufacturing companies and customers, and which often lead to production waste and economic losses.

For retail and personal service providers, in particular hairdressing, the presence of technical figures specialised in color is directly linked to the difficulty when retaining a clientele that is often unsatisfied because its expectations related to color are not fully satisfied.

On this basis, we have designed a higher training course, described as IFTS (Higher Technical Education and Training), that could develop highly colour-specialised professionals in the cosmetic products sphere and therefore be able to enter the aforementioned business realities and support them in overcoming relevant critical issues.


Poliestetico: a novel approach to education in the cosmetics field

Poliestetico di Milano is a professional training center accredited by the Lombardy Region and an equal professional institute recognised by the MIUR, it is located in Paderno Dugnano, on the outskirts of Milan, and was constituted with the aim of introducing new educational proposals and professional training of experts for beauty and cosmetic companies, enhancing the profile of these figures and their sectors of belonging, often mistakenly considered as secondary by public opinion or underestimated with respect to their economic potential and job offer.

Poliestetico di Milano was born from the will of a professional training institution and its managing partners to evolve and develop according to the vision proposed by an entrepreneur in the cosmetics sector, Giannantonio Negretti, creator of Humanistic Cosmetics and promoter of a new frontier in the training of operators in the beauty and cosmetics, which relies on science to increase satisfaction and consideration among customers and the public opinion, highlighting the social role of the operators and the services offered.

The courses provided by Poliestetico di Milano are aimed both at underage students in compulsory training, and at extra compulsory adult students who want to retrain or specialise in the reference sectors.

These courses cover both the areas of personal and cosmetics services. For the first area, we propose hairdressing and aesthetic courses aimed at both students in compulsory training and adults for the achievement of professional qualifications required to be able to operate in the sector; furthermore, the professionalisation courses of Tattoo, Piercing, Make-up and semi-permanent make-up complete this offer.

For the cosmetic sector, on the other hand, the offer currently includes a course of equal professional education with a focus on Industry and Crafts for Made in Italy in the chemical-cosmetic sector, it is a five-year path for obtaining the high school diploma, which prepares individuals with skills that can be applied in various sectors within the cosmetic industry. Additionally, as a Higher Technical Education and Training (IFTS) course, we provide the course which is the main subject of this presentation, namely Color Technician in the cosmetic industry.

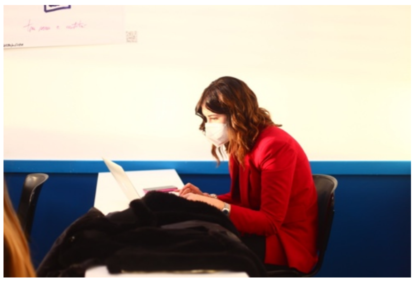
The IFTS course

The Color Technician Course in the cosmetics industry is a Higher Technical Education and Training (IFTS) course, aimed to meet the needs of the cosmetic sector and personal services companies, for which the training of specialised operators in the knowledge of color is now a crucial need. Poliestetico of Milan has therefore designed, together with some important partners, a path aimed at creating a "new" specialist technical profile: COLOR TECHNICIAN IN THE

COSMETICS INDUSTRY, a course lasting 1000 hours distributed over 500 hours of lectures and laboratory plus 500 hours of company training internship.
The project was developed in agreement with the IT department of the University of Milan represented by prof. Rizzi, with companies operating in the sector and also involves two important secondary education companies in the chemical field such as the Hensemberger Institute of Monza and the Molinari Institute of Milan. Subsequently, the project was approved and funded by the Lombardy Region as part of the POR FSE projects.
The course is aimed at students who possess a professional diploma (IV level EQF) or high school diploma (V level EQF), and is particularly financed for young people who are up to 30 years old and looking for a job.
It is particularly relevant is the teachers team which is made up of several important professionals from the work, education and training sphere and from excellencies among the university and business areas.

First edition





The first edition of the Color Technician course was launched on November the 22nd, in 2021, the classroom and laboratory lessons, including visits to industrial plants and trade fairs, ended at the end of May 2022. The students visited an important industrial reality operating mainly in the production of hair dyes and hair products, a lipstick manufacturing industry and a make-up product industry.

The course took place mainly in the classrooms and laboratories of the Poliestetico headquarters located in Paderno Dugnano, while part of the lessons were carried out in the training spaces made available by the Molinari Institute in its Milan office. Subsequently, the students started their internship in companies relevant in this sector, some are still in progress and will finish by next November 30th. Then the final exams will take place, presumably before Christmas holidays.

The participating class, excluding some students who retired in the first weeks due to logistical difficulties, is made up of 18 students of which 16 women and 2 men. Most of the students come from the four-year IeFp of wellness courses (9 students) and the rest come from various five-year education courses such as scientific high school, high school of human sciences, tourism, design and fashion institute and others; one student holds a degree and a specialist master's degree. Some of the students have already had work experience in the sector (3), others in similar sectors (the 9 working in personal services).

There were 500 hours of classroom lessons, of which about 40 in specialised laboratories and about 80 held totally or partially in English. The subjects delivered are listed below. The foreseen internship hours are instead 500, in which the students have been placed with different tasks and in different departments of the host companies, from research and development laboratories to production and quality control, from marketing to distribution, but always having to deal with the activities management related to the world of color.

The topics

The course educational section of classroom and laboratory lessons, provides within its training plan/curriculum some subjects specifically dedicated to chemistry and cosmetics formulation, including industrial, with the study of ingredients, their interactions and incompatibilities, and the characteristics of the most popular industrial cosmetic products. This section also guarantees a skin anatomy and physiology module that helps students understand the benefits and contraindications of using cosmetics on the skin. The focus on the industrial and cosmetics sectors, on the other hand, is guaranteed by the development of various dedicated modules such as the one on automated industrial systems, marketing and distribution and packaging of the products themselves, as well as specific modules on hair colouring and make-up. The issues of environmental sustainability of production, in particular in the reference sector, and safety in the workplace are also analysed in specific modules. Additionally, for a more economically scope, there is a module dedicated to Made in Italy and the financial aspects of production and the specific sector.

More scientific aspects of the course, inherent to the study of color, include Colorimetry, Color Measurement and Digital Color subjects together with the related ones dedicated to the Physiology of senses, in relation to the perception of color, and to Color Trend forecasting which explains the mechanisms that regulate color trends.

The course is completed by an English language module aimed at making students acquire a technical vocabulary and adequate language communication, and some modules have a more transversal-nature, such as job market orientation, team work and graphic creation techniques.

Conclusions

The IFTS course of Color Technician thereby constitutes an innovation in the Italian higher education courses panorama both in terms of training offer and professional figures in the market. In the first edition emerged both the interest of the involved sectors (cosmetics and personal services) regarding the issue and the attractiveness in terms of professional opportunities even for younger students, mainly women; the interaction with the internship hosting companies also helped us to understand how and where to go in order to improve the path, where to foresee a greater development of knowledge and skills. In particular, it is important that the participating students, before acquiring the scientific knowledge and skills related to color, have a consolidated scientific basis, especially with regards to mathematical and physical knowledge. Finally, although Color Technician is a figure who can adapt well to different areas of activity within the industrial realities of cosmetics, its natural "habitat" belongs to research and development laboratories where high technical-scientific skills can be highly valuable to other performing operators and therefore raise the final result in terms of quality of the offered products.

We are therefore already working on the course second edition, which we plan to start by the end of the current year.