# Colours, light and well-being: characterization of chromatic phenomena in collective housing.

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**ABSTRACT**

The objective of the study presented is to demonstrate the interest of chromatic and luminous analysis of a place in the pre-design phase. This analysis protocol is in line with the designer's ethic, which is to anticipate and respond to the conscious and unconscious needs of users, thus participating in the construction of a quality approach. Based on the case study of the "Bonamour" project (Capbreton, France), we question the value and interest of promoting a protocol that favours a benevolent and differentiated design approach. This will allow us to evaluate the relevance of the devices applied. In the end, the data collected and the recommendations applied to the project will allow property developers to progressively turn towards a more inclusive and sensitive design of lighting and colours applied in the residential sector.

**KEYWORDS** (Light design, Color design, Visual comfort, Protocol, Accompaniment)

**RECEIVED** 11/16/2021; **REVISED** 25/05/2022; **ACCEPTED** 13/10/2022

## 1. Introduction

### 1.1 Health and housing threats

The recent pandemic we have suffered is the sixth to hit humanity since the Spanish flu of 1918. According to ONU report, the frequency and severity of these global epidemics could accelerate in the coming years, due to our lifestyles and the incredible adaptability of viruses (Intergovernmental Science-Policy Platform On Biodiversity And Ecosystem Services (IPBES), 2020). In this exceptional health context, we have seen that housing conditions have had a greater impact than ever on our daily lives. We therefore realised that the problems linked to the quality and sharing of collective living spaces during a pandemic will be major issues in the future and will require the full attention of real estate professionals.

All the more so for many reasons, staying at home can be accompanied by multiple and varied disabilities, thus affecting quality of life (Eideliman and Gojard, 2008), (Piccoli et al., 2020), (ONU, 2020). In France, approximately 12 million people are affected by a disability, including 1.5 million by a visual impairment and 850,000 by reduced mobility, (Mormiche, 2001). Age is also a factor to be taken into consideration, as in 2050, metropolitan France will have about 70 million inhabitants, of which more than a third will be 60 years old, (Brutel, 2002). For all these people, the positive and reassuring perception of the daily environment must become an important issue. It is therefore necessary to adapt the environment of collective housing to people with different pathologies and their potential consequences on their habits.

### 1.2 Chromatic effects and methods of approach.

With this study we want to provide reflections on design issues such as the design of sensitive and inclusive built spaces. To do so, we focused on what inclusion means in creating the atmosphere of a place through its influences of colour and light. To this end, we defined that an inclusive atmosphere translates into situations of sensitive interactions understood as the plural and singular experience one has of a given place at a given time, influencing our sensations and quality of life. For many years, designers and authorities have been placing people and their plurality at the heart of architectural projects, based in particular on guides such as the Well Building Standard ('WELL Building Standard (English version). However, if we confine ourselves to strict compliance with the standards, since people do not meet any average, there are still many gaps. For example, in French standards (EN 12464-1 supplemented by NF X35-103), the only indications are that the age of people must be taken into account to define the lighting levels of work surfaces. In collective housing, Article 10 of the Order of 24 December 2015 imposes minimum characteristics to ensure average horizontal illuminance values measured at the floor along a usual circulation route, taking into account transition zones. It goes without saying that strict compliance with these standards does not guarantee the success of an architectural project in the perception of these users (Mudri, 2002).

### 1.3 Colours and lights: factors of identity and orientation.

In the literature of cognitive science 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 to the pathologies of people with disabilities has positive effects, but must respect a certain number of criteria such as a certain amount of light, contrasts and an appropriate spatial distribution (Damelincourt *et al.*, 2010). We have therefore hypothesised that colour and lighting devices in the architectural environment of collective housing could help with spatial orientation, particularly for disoriented people who are less receptive to conventional signage systems (Bay and Fayolle, 2020).

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.

## 2. Materials and methods

### *2.1 Color-matter, color-light*

The protocol presented is based on a combination of chromatic expertise (chromatic countertype) concerning the choice of materials, textures and finishes, favouring colour for its plastic character; and lighting (light

characterization) concerning the quantity and colour character of light, with particular emphasis on different colour temperatures. This study focuses mainly on the creation of the common spaces and the interior horizontal circulations. Indeed, the visual ambience of these spaces should create a sense of welcome, visual comfort and safety for all users, of all ages, day and night. The bi-disciplinary 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 method was divided into two stages:

*2.1.1 Step 1: Captures*

The surveys presented were carried out on 26 June 2019 in Capbreton (Landes, France) over a period of 8 consecutive hours on the site of the future "Bonamour" residence built by the property developer SOBRIM (SOBRIM - HARANAM).

The first phase consisted of collecting photographs of the site. The inventory of the existing site is an essential phase before any project. Equipped with a camera (Canon EOS 2000D, Adobe rvb colour space), this preliminary chromatic analysis was accompanied by a walk on the site which aimed at establishing a diagnosis of the architectural and vegetal environment surrounding the project in order to transcribe the essential elements. 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 chromatic studies employ photographic investigations to support colour surveys. In our case, photography was used in two approaches, one aimed at establishing an inventory of surrounding urban colours and forms, the other a colour and light diagnosis in order to judge the appearance of the site under cyclical conditions. This step was a way to transcribe and analyse the experience of a space. The second phase consisted of referencing the colours of the site with the help of countertypes. In our study, the colour survey consisted of observing the colours that make up the environment and the architectural elements surrounding the project in order to compare 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. The third phase consisted of a series of measurements to characterise the lighting environment of the site. This pre-assessment was carried out at three different times of the day (10:00, 14:00, 17:30) to measure the light amplitude. In addition, in order to analyse the distribution of light in the space, the space was divided into several areas of the site. This series of measurements was carried out with the IRC CL-70F chromameter, allowing the collection of all light values. A video-luminance meter (CANON EOS 2000D, Fish-eye 4.5mm 1:2.8 lens + PHOTOLUX 3.1 software) was also used to identify areas that may be sensitive to glare and shadows caused by future buildings.

*2.1.2 Step 2: Creation*

The first phase consisted in analysing the elements collected: evolution of the existing light according to the architectural and plant masks, as well as the chromatic identity of the site (see Figure 1).

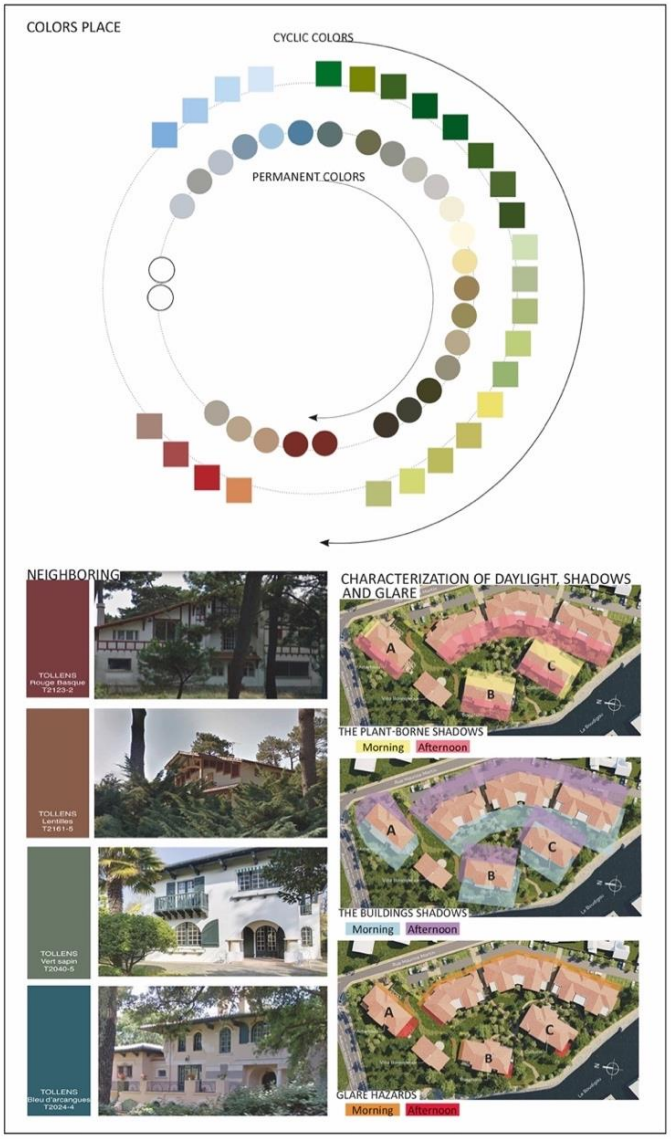


*Fig. 1. Environment study, Capbreton, France.*

Each environment has a unique identity, of which colour and light are part. The mission of the colour designer 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 promoter's wishes in terms of 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 and the sky (etc.).

The second phase consisted of recommending ambiences adapted to the site, using chromatic ranges, materials and lighting systems that favour the safety and visual comfort of all the 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 site, which we then matched with the paint and plaster manufacturers' colour charts used for the project. Thus, a visual and aesthetic atmosphere was conceived around the spirit of the place, the chosen shades are sublimated by the contribution of contrast around several soft and affirmed tones inspired by nature which create a coherent harmony with the vegetation present on the site. These prescriptions led to the creation of three specific colour palettes for each building in the project (see Figure 2).

Inside, the chromatic combinations are composed of five shades, but established on a dominant trichromy , varying at each level, thus avoiding any visual disturbance 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. Thus, the luminance indices of each recommended colour are between 0.6 and 0.9 for light colours and between 0.2 and 0.45 for dark colours, and finally, a contrast of 70% has been respected between the various important media so that they can be perceived by a visually impaired person, whose sensitivity to contrasts is still operating. Here, light colours are used for large surfaces and dark colours for small surfaces or accessories to allow better discrimination of spatial elements. Some of the contrast values are not equal to 70%, but they have been accepted because of a negligible margin of error. The creation of these differentiated harmonies allowed us to design circulation spaces with chromatic variations for each level, favouring intuitive orientation as well as efficient and comfortable reading of the movement chain for all inhabitants.

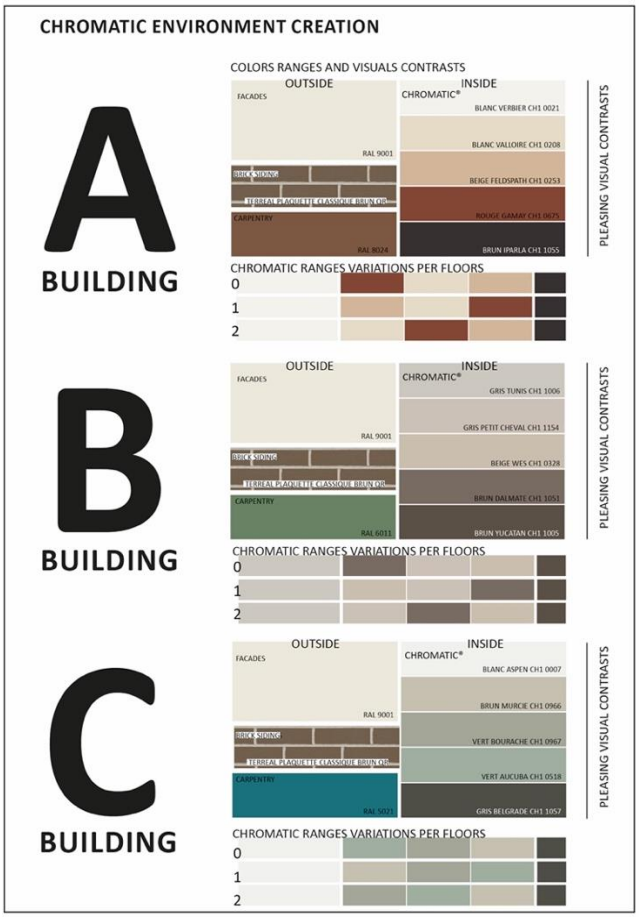


*Fig. 2. Chromatic environment creation.*

These harmonies were also accompanied by a lighting project. This was studied so that the quantity and quality of light would meet the needs of all inhabitants, because the visual, light and lighting needs of people over 75 are not those of a 50 year old, and even less so of a 30 year old. Due to the physiological ageing of the eye and the retina, more light is needed to perform certain daily tasks. This need is increased in the case of diseases such as glaucoma, cataract or eye damage caused by diabetes or medication. As a result, from the age of 55 onwards, the amount of light required is 300% higher than at the age of 25, and this for an equivalent level of visual performance ,(Association française de l'éclairage, 2020). For this reason, we recommended an average of 300 lux on the floor throughout the chain of movement of interior spaces (entrance halls, corridors, staircases), while taking care to accentuate certain

important areas or elements by light contrast, such as the highlighting of signage elements, access to lift doors and wall decorations serving as visual and orientation markers in long corridors. This was achieved through the use of LED general and ambient lighting systems that provide both direct and indirect light to accentuate the volumes while not producing harsh light-dark transitions. Finally, we chose to apply a colour temperature of approximately 3000 Kelvin; this choice was supported by the fact that we plotted this data on the Kruithof curve (Viénot, Durand and Mahler) in order to deduce whether the visual ambiences are considered comfortable for the majority of observers (see figure 3).

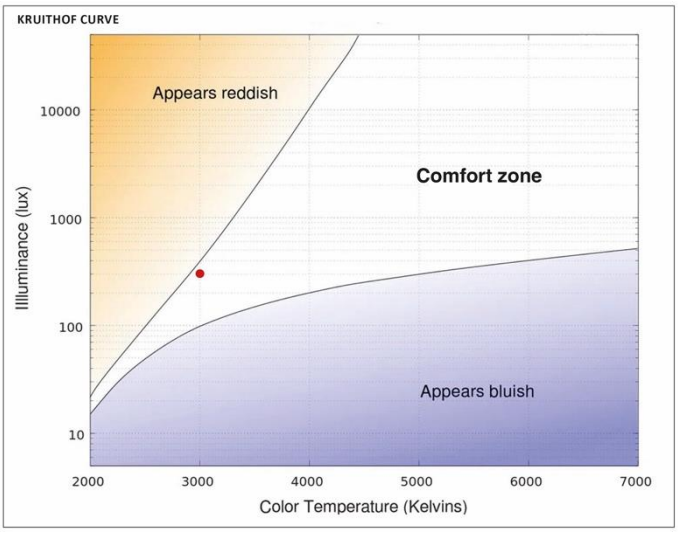


*Fig. 3. Choice of illuminance and colour temperature to create a comfortable visual environment.*

In addition, recent research has shown consistent effects of lighting characteristics on perceived ambience. Increasing illuminance would result in a less difficult and more vivid perception of the overall ambience as would the application of warm white light (2800K) which would be perceived as more comfortable than cold white light (6000K).(Kuijsters *et al.*, 2011).

Also, concerning the choice of materials, we studied their LRV (Light Reflectance Value) in order to recommend suitable finishes in all the circulation zones according to the natural light input and thus not to generate too much 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. Result

The different phases of analysis helped to demonstrate how qualitatively and quantitatively the project could be perceived by the inhabitants ,(INSEE, 2017). Mainly thanks to the exposure of the buildings, their light contributions in relation to the different masks, and the architectural and landscape aesthetics of the overall environment.

The interpretation of these results allowed us to prescribe effective and coherent lumino-chromatic ambiances, taking into account the constraints linked to the respect of the local architectural aesthetics found around the site, the respect of visual contrasts as well as the hypothetical contribution of natural light entering each building. This design phase, of course, complies with current standards in the field of lighting design for this type of space, but it calls for an experimental construction method (Pfeiffer, 1966), taking into account several factors intrinsic to the project:

- The analysis of the colour and light characterization of 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.

The outcome of this protocol was the creation of a construction file and a detail book, intended for the client in order to transcribe the information gathered into technical prescriptions, colouring principles and effective lighting of the future building (see Figure 4).


*Fig. 4. Results obtained to facilitate the assimilation of space and movement.*

We hypothesize that this bidisciplinary experimental expertise of chromatic and luminous characterization within its future circulation spaces will generate more visual cues and comfort of use thanks to this protocol.

## 4. 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, standardization of practices, specific needs related to people with disabilities, 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, even monotonous, colours and materials, and struggle to install lighting that is sufficiently effective, comfortable and aesthetic in common areas. With the help of this study, we are beginning to awaken designers to the challenges of colour and light. Because together, beyond their simple aesthetic contribution, they make it possible to secure and make efficient the circulations while allowing the inhabitants to plunge into singular universes where the atmosphere becomes a factor of wellbeing and cohesion.

## 5. Conclusion

In the next few years, we will repeat these measurements in the built collective residences and a comparative study will complete the research-creation protocol studied in this article. This comparative study will take into account the values obtained in the old residences and those that were built using this protocol. This study will be completed by a questionnaire intended for the inhabitants, where they will be asked to answer questions relating to their state of health, their general satisfaction with the care given to the (interior) environment of their residence and finally to describe in detail their long-term visual impression of the common spaces. They will then be asked to evaluate their visual comfort in specific places and times of the day using sensation grids.
This will allow us to compare this feedback with measurements taken in situ in order to correlate the metric data collected with the visual atmosphere felt. This study will enable the property developer to ensure the efficiency of its approaches and to continue to systematically and sustainably design 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.

## 6. Declaration of funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or non-for-profit sectors.

## 7. Declaration of conflict of interest

The author has declared that no competing interests exist.

## 8. Acknowledgement

I thank the LAPLACE Laboratory of the Paul Sabatier University in Toulouse, France for making the experiment possible by providing tools. I also thank the company SOBRIM for allowing me to carry out this study and for the interest shown in these results. Finally, I would like to thank them for their willingness to promote and develop their university research within their future real estate programmes thanks to the HARANAM approach.

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**Christelle Infantes**, DPLG architect and head of the Haranam research and development department, within the company Sobrim from 2017 to 2021.

## Licensing terms



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