Colours and aircraft interiors. Design scenarios for a regional aircraft cabin.

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COLOURS AND AIRCRAFT INTERIORS. DESIGN SCENARIOS FOR A REGIONAL AIRCRAFT CABIN.

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ABSTRACT

The paper aims to investigate the use of colour and its perception within the cabin of a regional aircraft used for short distances and it is divided into two parts. The first part presents an analysis of the literature and the state of the art on the use of colour both within the aeronautical sector and in comparable sectors, such as that of interior architecture, where over the last few decades researchers formulated different theories of approach. The case studies examined show that, today, the choice of using colour is mainly based on marketing factors linked to the corporate branding of airlines, with a lack of sensitivity to human factors. The literature on colour, on the other hand, suggests that the different tones of colour have a strong impact from a physiological and psychological point of view, factors that must be taken into consideration to improve the experience of wellbeing on board, defining a framework of requirements. The chromatic hypotheses were, then, examined and compared through a preliminary perceptual test conducted on a sample of 20 subjects aimed at evaluating and defining guidelines for approaching the colour project. The objective of the guidelines is the construction of chromatic design scenarios defining a comfortable environment from the visual point of view and capable not only of generating a pleasant, comfortable travel experience but also a feeling of security and limiting the typical unwanted perceptions related to flight. The paper is part of the dissemination of the H2020 CASTLE project (CAbin Systems design Toward passenger welLbEing).

Keywords: colour trim design, UXD user experience design, HCD human centred design

1 INTRODUCTION

This research, through a holistic approach between psyche, culture and vision science studies colour as a component for the design of the passengers' level of comfort in the airliner cabin.
In the design of colour it is in fact necessary to take into account the psychological and expressive component, as well as to attribute the right weight to the function by elaborating rational solutions to the chromatic problems, searching for the most suitable colour for each environment and function based on the needs of the end user. Each colour produces different effects depending on the use and context in which it is placed, and it is also for this reason that it is not entirely correct to judge combinations as right or wrong. "The colour combinations must instead primarily be used for their function, which has to do with visibility." [1] Colour is looked at from points of view: that referring to the psyche and culture, in which also the subjective component of perception at the entrance, and the objective component, described by the science of vision. The project, because colouring is

also a project activity, it is up to mediate between the two, wearing the dress of the scientist and that of the creative to design products (artefacts) that have a recognizable identity in the combination of shape, material and colour [2]. Through these three components, always in relation to each other, the designer communicates the function, the expressiveness and the meaning of a product, so much more forcefully as the relationships will appear evident, in harmony or in contrast. "Harmony is perceived when the single elements of a whole are related to each other and respond to a common principle [...] Harmony is interaction both of the like and of the contrary, it is a completion, an increase, a cancellation. A common parameter that makes comparison possible, without which things would only be different, unrelated, meaningless for each other" [3].

2 COLOUR AND COMFORT IN THE AIRCRAFT

What are the main problems to be faced in the chromatic design of an airliner cabin in order to improve the travel experience? Peter Vink and Klaus Brauer in their book "Aircraft interior comfort and design" define the chromatic component of the cabin (walls, seats, etc.) as an integral part of travel entertainment. [4] Research conducted by DOXA in 2011 concerning the fear of flying has shown that in Italy 53.5% of the population suffers from aerophobia and flight-related disorders. [5] The phases in which there is greater fear are: take-off, landing, flight over the sea, poor visibility, night flight, wind, disturbance and crowding. Some companies offer combinations of colour (and light) aimed to create a more pleasant and comfortable atmosphere in order to distract the passenger from the common disturbances that arise when traveling. We are only at the beginning of an interior design for the flight that promises to be full of innovative experiments that cross systems and technologies to ensure better well-being, but also to distract the passenger from the increasingly crowded conditions of the aircraft and less space available. Martin G. Helander, a researcher at Nanyang Technological University in Singapore has long wondered about the comfort factors or discomfort of the sessions. The research he conducted resulted that the perception of comfort of a seat is closely linked to the aesthetic aspect, much more than to the ergonomic characteristics of the seat. [6,7]. Promising instead the search for coloured light in the cabin (RGB LED) after a somewhat too noisy start of the first experiences in multicolour, a subject that is also the subject of the CASTLE research (CASTLE is part of the Clean Sky 2 Programme (CS2). CS2 programme has been launched under H2020), but for brevity will not be treated here.

2.1 The perception of comfort/discomfort

Comfort is the feeling of the level of well-being perceived by the user in a given environment, whose main factors used in the design of the building refer to light, sound, heat and air quality [8]. Declining this approach, in "Comfort and Design: Principles and Good Practice" [9] are listed the factors that influence the overall comfort perceived during the flight (thermal, acoustic, physical and sensorial, visual, discomfort). Therefore, it is not only the physiological aspects that need to be considered, but also the psychological and socio-cultural aspects, which are just as important and are rarely mentioned. The methodological model called "pyramid of discomfort" (Bubb, 2008) indicates how anthropometry is unimportant if the other aspects at the base of the pyramid are not addressed. Vink and Hallbeck, in 2011, presented the so-called "Comfort model" [10]. This model simplifies the steps that influence the comfort/discomfort experience, starting from the observation that the experience of "comfort or discomfort" is different for each person and that the assessment is all the more effective if referred to when a subject/ person, within a specific space/environment an activity begins, interacting with one or more artefacts. Interaction with the product and immersion in the environment with certain characteristics can cause internal effects in the human body,

such as changes in tactile sensations, blood flow and muscle response or that induce changes in body posture. The perceived effects are therefore influenced by the responses of the human body but also by the physiological and cultural expectations of the subject. The result is feeling comfortable, uncomfortable or feeling no sensation. Continuing with the analysis of the user experience, Naseem Ahmadpour (2014) [11] believes that perception is filtered by psychological ("Peace of mind") and physical ("physical wellbeing") factors including "proxemic", understood as the control of personal and social space, "pleasure", "satisfaction" associated with efficiency, effectiveness and usability and "association" with regard to the interaction between the environment and the personal characteristics of the subject (colour is one of these). Finally, it should be emphasized that the measurement of these factors is important not only because it affects the passengers satisfaction or discomfort at the time of the experience, but it can affect his future choices and those of other passengers, through word of mouth and today with increasing frequency the social networks. How to measure these factors? According to Wilson J.R. [12], the test methods can be divided into direct observation methods and indirect observation methods. The first are based on techniques of observation and evaluation of user behaviour during interaction with the product. "Objective" methods are also defined, as they are able to provide exactly the objective information and consist in the collection of data relating to the behaviour and performance of users during the execution of specific activities. Indirect observation methods, on the other hand, allow us to gather information about the interpretation that users give to what they are doing. These are also called subjective methods and relate to reporting on behaviour, attitudes and opinions of users. Their subjectivity refers to the fact that the information produced is filtered by the observer's evaluation. To these factors, the CASTLE research has given ample room for study in the metadesign phase, anticipating the design project, through a comparative evaluation of multicriteria indexes which examined 20 last generation aircraft for passenger transport of line. The object of the evaluation was to define for each factor the thresholds indicative of the current standard, in order to overcome them even taking into consideration a scenario of anticipation of the future that foresees what will be the achievements in terms of innovation, trends and future behaviour of users between about 10 years, date of a possible entry into the aircraft market now in the project. The comparative evaluation factors can be summarized as follows:

- thermal comfort, linked to the microclimate and the possibility of user customization the air speed and temperature;
- acoustic comfort, measured on the absorption capacity of surfaces due to diffuse noise and non-interference between passenger voices and in relation to the noise of engines and devices; in the next phase also the evaluation of the discomfort induced by vibrations and sudden movements;
- physical and sensorial comfort, in turn articulated in an extensive range of parameters: dimensional, with regard to the spaces for sitting and walking passengers; perceived security of the solutions offered; of sensory perception of stimuli caused by the materials used and surface treatment;
- visual comfort, analysed through the simulation of "what I see and what I feel" during the main stages of the journey, from the entrance to the leaved the cabin at the end of the flight: tunnel effect, search for the place, field of vision beyond the windows, recognition perspective of the signs and the presence of the on-board personnel. But to the ergonomic visual comfort is also added the well-being generated by the lighting levels of a room and the chromatic relationship between the elements present in it, aim to satisfy the user's physiopsychological perceptive needs. [13]

The visual input therefore influences our experiences and the first perception of a more or less comfortable environment is linked to it. And among the indices of perception, the colour

certainly has a strategic importance. Therefore, entering the cabin of an airplane, the "first visual impression" (the eye-catcher) is of fundamental importance for what will be our evaluation of the flight experience. And on this first glance colour has a notable incidence, not only in terms of expressive pleasantness but also in terms of environmental perception [14].

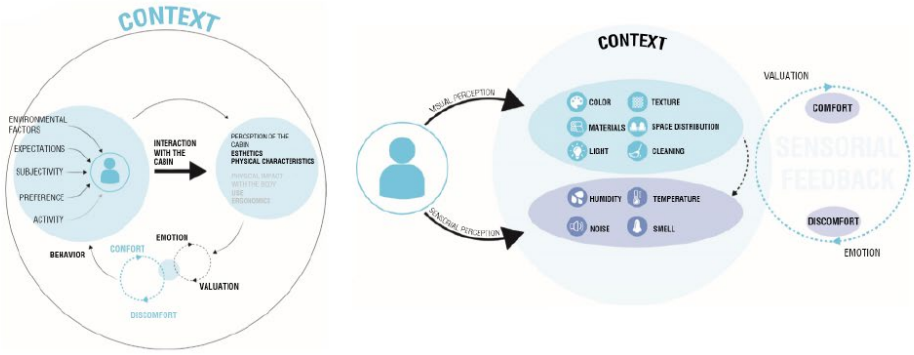

Figure 1: Psychological and physiological factors in the perception of comfort in the cabin.

2.2 The chromatic design of the cabin

Most airlines choose the colour of their set-up not based on a psycho-physiological project but with other motivations.

a. *Colour brand*. Very common are the colours associated with the flag mark. This design choice, if well harmonized, can be pleasant, livening up the environment and creating a pleasant memory and associations experienced with a particular company. Most of the time, however, a heavy and physiologically incorrect visual imprint results.

b. *Colour culture*. Some companies, on the other hand, use colours, fabrics and decorative motifs related to their local culture. A choice of this type can be interesting as it immerses the traveler in what will be his destination and attributes to the colours the role of communication of a meaning that can be clearly understood.

c. *Colour context*. Still others use the "colour context" which refers to the colour applied to interact with the senses, creating harmony and visual comfort. Some airlines choose colours with the formula of contrast, also known as "antinomy": volumes and clear set-ups to communicate lightness in contrast to dark catwalks to evoke solidity and presence of gravity; light and light colours to emphasize the prestige of the business class compared to the less dirty colours for the economy. To better understand what role colour has in the configuration and communication of the cabin environment, it was deemed appropriate to analyse the chromatic criteria of the exhibition promoted by the top 30 companies in the world, according to SkyTrax (British research company), stood out for the quality of the service. [15] The chromatic choice, as previously mentioned, has been included in the 3 types of approach (colour brand, colour culture, colour context) and as detection products the seats and headrests and the nacelle, the latter articulated in walls, have been identified ceiling and walkway. Recent experiences highlight how Interior Design, a holistic discipline geared to human factors, is called to design passenger cabins taking into consideration the relationship between man and the environment in order to create well-being and make the flight experience pleasant and attractive for the future. This term is connected to the ability to combine colour and light in the construction of real experiential environments, capable of involving the passenger and distracting him from any inconvenience related to travel. The main tools available to create experience are:

- *colour*: used to make the environment attractive, to create harmony, sometimes to emphasize the philosophy of the airline or to create associations between hue and meaning;

- *artificial light*: the travel experience is amplified with the use of artificial lighting, useful for regulating the phases of flight, interacting with the circandian rhythm or with the external environment. A field still to be explored;
- *virtuality*: visual communication experiments multiply, equally in other sectors, through a mix of elements such as light, colour, multimedia and virtual reality. The main objectives of these productions are: the creation of a "memorable" travel experience and that can also distract the passenger from the typical flight-related disturbances;
- *pattern*: designing interior cabin surfaces by repeating ordered and organized signs and patterns (the pattern) is one of the most interesting activities for the designer. The pattern can be created at different scales and with different meanings: on a larger scale, for example, when the seat, or a group of seats, is used as a minimum unit of the cabin's colour composition; but the pattern also serves to modulate the space, to indicate paths and escape routes.

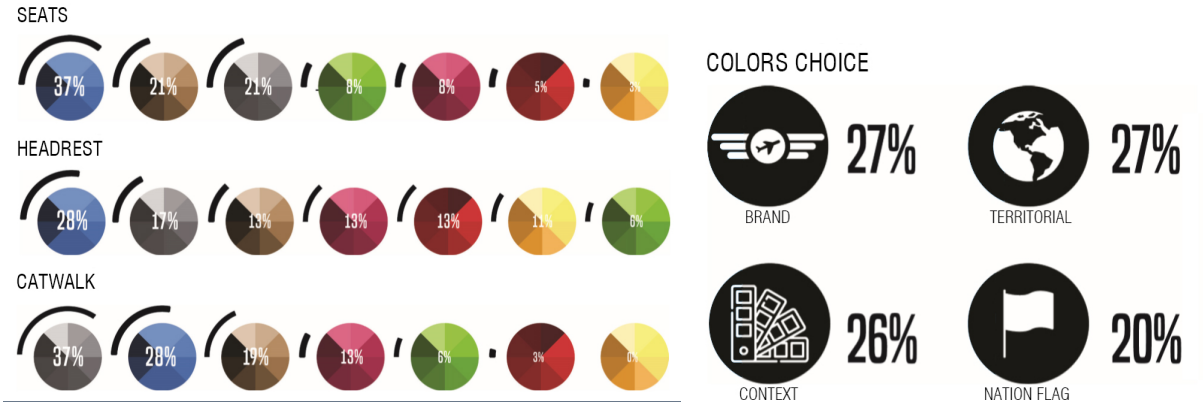

Figure 2: Colour trends detected in the cabins of the main airlines.

3 GUIDELINES

In the CASTLE activity, the chromatic study is dealt with according to the performance methodology that provides for the determination of the response to the psycho-physiological needs of environmental comfort and the corresponding requisites and performances required through the conscious colouring of the components of the cabin environment (walls, ceiling, etc.). The evaluation is instead still in an initial phase, so the variables identified by the metadesign of the "colour pattern" were measured only through a preliminary perceptual test conducted with 40 subjects and considered only indicative of the correctness of the ethnographic questionnaire that will be administered also with the help of the virtual immersive reality in a second next phase to 100 subjects, divided between experts and non-experts.

3.1 Needs for chromatic comfort in the cabin

The search intends the colour to the service of:

- *visual comfort:* balanced and harmonious visual scenario between colour and surface illumination;
- *perception of space*: limiting the claustrophobic sensation of the "tunnel" effect of the nacelle and the relative narrow spaces, creating new apparent dimensions of space;
- *perception of comfort*: widening the role of colour to the perception of smell, temperature and noise;
- *relaxation and well-being*: the colour influences the perception of skin colour which in mental association can induce relaxing or energizing behaviours;

- *perception of security*: search for the colour matching the security status to be communicated, component by component;
- *recognizability of spaces and functions*: colour with delimiter role and marker of spaces and functions;
- *recognisability of hygiene*: masking colour or emphasizing hygiene conditions? The answer is not obvious: it involves the performance of coating materials and perception.

3.2 Requirements and performances requested to the cabin space components

The cabin under study must therefore possess a series of requirements aimed at satisfying the needs listed by operating on the various components of the interior of the cab:

- *ceiling and luggage racks*: conceived with shape and volume in continuity, they will have identical light colours with an average reflection index so as to diffuse the light and restore a perception of airiness to the ceiling and decrease the "apparent weight" of the luggage racks on the seats;
- *side walls*: organized with windows in groups of 4 contoured, it knows a dimmable LED strip in order to create the perception of "rooms" in contrast to the "tunnel" effect perceived in the cabin. For concept homogeneity, the colour will be identical to the previous one described for ceiling and luggage racks.
- *back walls*: designed, according to the Gestalt theory, more saturated than the side walls, to create an effect of widening the transversal dimension of the space and of approaching the wall, in contrast to the "tunnel" effect generated by the larger size longitudinal of the cab (fig.3);
- *walkway*: designed with a colour similar to that of the back wall to suggest continuity between different floors. Being the darkest hue found in the cabin, it reinforces the concept of harmonious composition related to gravity: the one in which the heavy masses, in this case the saturated and dark colours, are at the bottom and the lighter, lighter and less saturated ones, at the top;
- *seats*: in order to reinforce the perception of the "room", creating rhythm and breaking the "tunnel" effect, the basic module of the chromatic pattern is made up of 3 rows of seats that will have the same colour declined in saturation/clarity and organized in rhythmic sequence.

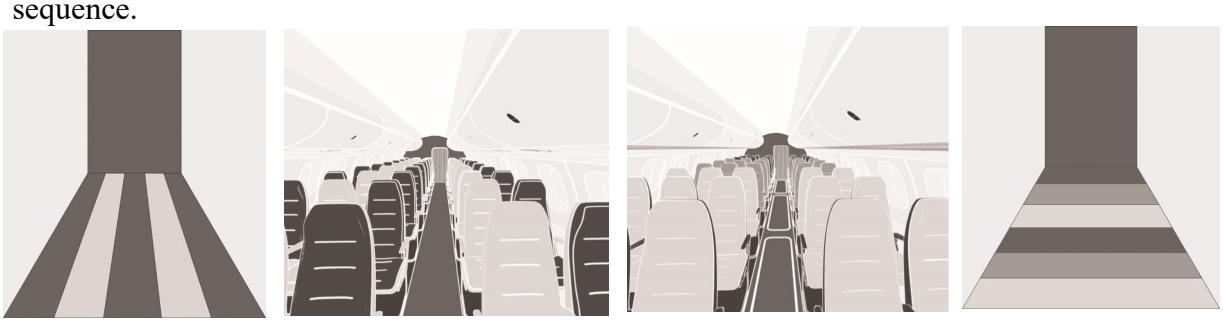

Figure 3: Perception of the dimensions of the cabin in the Gestalt comparison between chromatic organization for columns (left) and for rows (right).

4 DEFINITION OF THE METADESIGN TEST

Preliminary phases of the first metadesign assessment test on the role of colour in the cabin:

1. *Choice of the problem and definition of the hypotheses*. Phase dedicated to the definition of the object of investigation. In the six proposals of patterns and colours associated with them, hypotheses are formulated on how colour can affect not only the perception of space but also comfort, time, noise and temperature.

2. *Formulation of the test*. Phase in which the sample of subjects (target) and the instruments to carry out the test are identified: textual structure and visual instrument (3D models in sequence).
3. *Data collection.*
4. *Data encoding and analysis*. In the third and fourth phases, after having submitted the subjects to the test, the answers are aggregated with a return in graph form.
5. *Interpretation of results*. It is the phase that leads to validation or feedback correction of the hypotheses formulated.

4.1. Metadesign test

The test was conceived as a preliminary questionnaire in order to understand how the metadesign concept of the subdivision into "rooms", set up with different colours and scalar nuances influence the perception of the organization of space and other psycho-physiological sensations. The subjects (including 20 males and 20 females) will display the images shown on a screen of 120x90 cm size. The test was divided into 3 sessions:
1. *Comparison between standard and new concept*: in the first part, two images depicting two cabins to which the colours currently used most in booth setups, and a third with the chromatic and spatial sequence-only solutions organized according to the "rooms" concept. Subjects are invited to say in which of these environments the back wall appears closer to the observer making it perceive the environment as wider;
2. *Perception of space*: in the second part different shades of colour have been proposed, each represented with 2 possible sequences. The subject was asked to express his own judgment in terms of the breadth of the perceived space. In preview and without knowing the question that would have been asked, the subjects could visualize the 12 hypotheses, for ten seconds each.
3. *Perception of comfort and feelings*: in this session on sensations, the subject was asked to express an opinion on how space and environment were perceived in terms of stress, comfort, harmony, elegance, and safety, assigning, a value from zero to five for each of these factors.

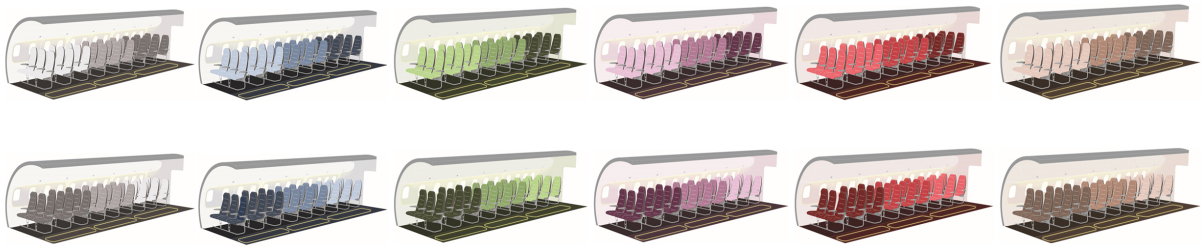

Figure 4: The six hypotheses of association between patterns (3 rows of seats) and colors of seats and cabin surfaces.

5 RESULTS AND CONCLUSIONS

The perceptive test conducted in the metaprojective phase confirms what has already been widely emphasized in literature: colour influences the user's level of comfort and, his entire from a sensorial perception point of view, his whole travel experience.
From the point of view of the pattern, the creation of "rooms" through the use of alternating colour on the seats and the sought-after contrast between walls, side windows and back wall, makes the environment perceptively wider, mitigating the typical perspective connected disorder to the tunnel effect. This optical illusion of amplitude can be increased through the use of ground lighting and the contour of the portholes. In terms of colours, the results of the test relating to the question of matching a colour with sleep, reading and working activities highlight studies concerning the influence of colour on the psyche: the reds win only in the

activity of the work; the blues and the greens emerge in the activity of sleep, while the pure greys and the dove greys are combined with the activity of reading mainly. A new series of test in a semi-immersive 3D virtual environment at the Digital HD Laboratory of the Polytechnic of Turin.

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