Fly in color. A chromatic “model” for the cabin of a commercial aircraft

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ANVUR Agenzia Nazionale Valutazione sistema Universitario e Ricerca
APeJ Academic Publications eJournal
BASE Bielefeld Academic Search Engine
DBH Database for statistikk om høyere utdanning
DOAJ Directory of Open Access Journals
EZB Elektronische Zeitschriftenbibliothek Regensburg
JURN Search tool for open access content
ROAD Directory of Open Access scholarly Resources
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PEER REVIEW PROCESS
All articles submitted to the Color Culture and Science Journal are peer-reviewed according to the following procedure:
First review level
The Associate Editors evaluate each article to determine if the topic and content are of interest to the Journal. Once the article passes the initial review, the Associate Editors select several reviewers from the Editorial Board based on their expertise in a particular subject area or topic.
Second review level
Two or three experts review each article with a blind peer-review process where the reviewers are kept anonymous. Reviewers are asked to evaluate the manuscript based on the following criteria:
- Originality
- Relevance to Journal's aims and scope
- Technical merit and/or validity
- Soundness of methodology
- Completeness of the reported work
- Conclusions supported by the data
- Correct acknowledgment of the work of others through reference
- Effectiveness of the manuscript (organization and writing)
- Clarity of tables, graphs, and illustrations
- Importance to color researchers
- Relevance to color practices

If the article is accepted with major revisions, the author(s) are asked to improve the article according to the reviewers' suggestions. The revised article will then be submitted for further review.
After collecting the reviewers' reports, the Associate Editors recommend the acceptability of the article to the Editor-in-Chief.

TOPICS
The CCSJ accept papers on a wide range of topics on color, including and not limited to the following:
1. Color and Measurement/Instrumentation. Colorimetry, photometry and color atlas: method, theory and instrumentation; quality control and food coloring, dyes, organic and sustainable color.
2. Color and Digital. Reproduction, management, digital color correction, image processing, graphics, photography, film and video production, printmaking and 3D print, artificial vision, virtual reality, multispectral imaging, data visualization. Light field imaging. Multi-sensor fusion. Color localization, recognition, HDR imaging, ADAS systems.
3. Color and Lighting. Metamerism, color rendering, adaptation, color constancy, appearance, illusions, color memory and perception, color in extra-atmospheric environments, lighting design, lighting technologies, visual comfort.
4. Color and Physiology. Mechanisms of vision in their experimental and theoretical aspects, color vision and color appearance, deficiencies, abnormalities, clinical and biological aspects, synesthesia, health, well-being.
5. Color and Psychology. Phenomenology of colors, color harmonies, color & form, perceptive, emotional, aesthetic, and diagnostic aspects.
6. Color and Production. Food and beverages, agriculture, textiles, plastic materials, ceramics, paints, gemology, color in the food industry.
7. Color and Restoration. Archaeometry, painting materials, diagnostics, and conservation techniques, restoration, and enhancement of cultural heritage.
8. Color and Environment. Representation and drawing, urban planning, the project of color, architecture, interior design, landscapes & horticulture, color and architectural syntax, territorial identities, biodiversity.
9. Color and Design. Furniture, CMF design, fashion, textiles, textures, cosmetics, food design, museography.
10. Color and Culture. Arts and crafts, history, philosophy, aesthetics, ethno-anthropology, graffiti, geology, sociology, lexicology, semantics, anthropology of vision, food culture and heritage, color naming.
11. Color and Education. Pedagogy, didactics of color, aesthetic education, artistic education.
12. Color and Communication/Marketing. Graphics, communication, packaging, lettering, exposure, advertising.

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Editorial

Dear Readers,

While entering the Journal's 11th year, we are glad to announce that the review of our Title is complete and that Cultura e Scienza del Colore – Color Culture and Science Journal has been accepted for Scopus.

In the last two years, the Editorial Team worked hard to improve the quality of the Journal to make it suitable for an internationally recognized database like Scopus. Scopus is Elsevier's abstract and citation database, launched in 2004, and it covers over 36,000 titles from more than 11,000 publishers in top-level subject fields. All journals covered in the Scopus database are reviewed for sufficiently high quality each year according to four numerical quality measures for each Title, like h-Index, CiteScore, SJR, and SNIP.

In the last years, we improved the Journal through different activities. We translated all the Journal's abstracts into English, especially those from the first years, specified the detailed affiliations of the board members and editors, and took different steps to raise the profile of the Journal internationally. In conclusion, we improved citations by other titles currently covered by Scopus (in May 2022, CCSJ citations in Scopus were 4, and in May 2023 were 34). CCSJ's article abstracts reached 1,400 readings (October 2022) and received an average of 29 submissions per year, with an acceptance rate of 54%. The Journal today has more than 180 users, and the numbers are growing.

Now, after the Scopus onboarding process, which will take a few weeks, all the CCSJ contents from 2019 will be included in Scopus (with some possible exceptions). Nevertheless, this step is just the start of a broader process that will raise the profile of CCSJ, and we still need you all to promote our Journal, broadcast the published articles, and be proactive in involving new authors.

In 2019, we moved the journal web management to the Open Journal System (OJS). This allows a better indexing of the published articles and guarantees compatibility with the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH). Since our start, we have published 15 volumes for 20 issues, adopting the new numbering that publishes one volume per year with two or more issues yearly in 2019. Since 2015, we have applied blind peer review; since 2016, we have introduced the Digital Object Identifier (DOI) system. In 2020, we reviewed our archiving policy to guarantee long-term access to our issues, making agreements with the Biblioteca Nazionale Centrale di Firenze (BNCF), Italy's main official public library.

Having reached the goal of being in Scopus, we remember that our Journal is also included in other databases: ANVUR, APeJ, BASE, DBH, DOAJ, EZB, and JURN. We also recall the importance of the concept of diamond open access under which our Journal is published: all the published papers are open access, and the Journal is free for readers and authors. This goal is possible thanks to the voluntary work of some members of the Associazione Italiana Colore in the editorial committee. We thank our associate editors and the President of Associazione Italiana Colore, Marcello Picollo. A special thanks goes to Chiara

Storti of the BNCF, to Filippo Cherubini of IFAC-CNR, who manages the OJS, and to Andrea Siniscalco, the vice-president of our publishers, for the graphic support. Furthermore, a big thanks goes to the developers of the OJS, the Public Knowledge Project (PKP), which is a partnership between the University of British Columbia, the Simon Fraser University, the University of Pittsburgh, the Ontario Council of University Libraries, the California Digital Library and the Stanford University.

Enjoy the reading.

September 2023

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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

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1. 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 the 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 (2012), 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, and 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, behaviors 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.

2. Fly in color. The importance of a color design

There are two approaches to the project which see, on the one hand, through the use of lights and colours, the creation of real experiential environments, capable of involving the passenger and mitigating the traditional visual discomforts associated with air travel, such as the claustrophobic sensation generated by the reduced dimensions of the space and by the perceptive insecurity determined by the tunnel effect linked to the prevailing longitudinal dimension of the passenger compartment. And on the other, trying to push this research towards the creation of virtual relationships with the outside, as in the simulations of artificial skies projected onto the ceiling and in the 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 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)

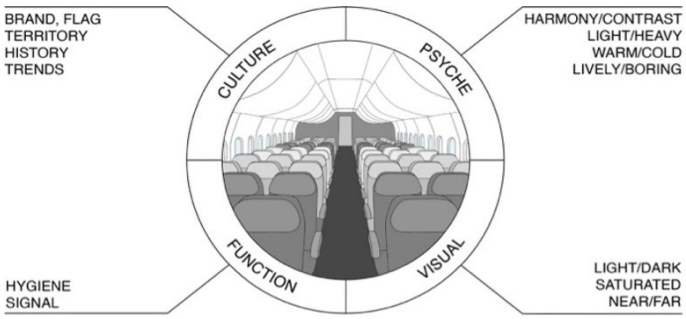

Fig. 1. The four perceptual components of color in commercial aircraft cabin.

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 (still valid in 2023) on the top 30 companies in the world according to SkyTrax (British research company)[1], 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 (Fig. 2);

Fig. 2. Interior of Boieng 737-800 in Ryanair color.

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 (Fig. 3) which uses colors that reflect the warm colors of the territory (sand) and the sea (blue);

Fig. 3. Interior of Airbus A320 in Etihad Airways color.

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 (Fig. 4);

Fig. 4. Interior of Airbus Jets 350XWB in Pininfarina color.

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. 5).

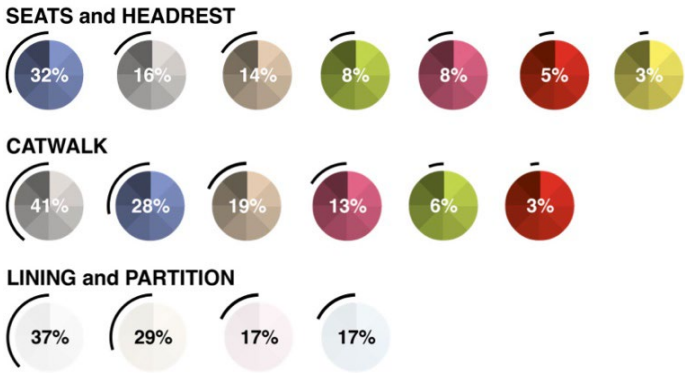

Fig. 5. Prevalence of colors in the outfitting components of the 30 aircraft selected by the SkyTrax 2019 report.

3. 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. 6).

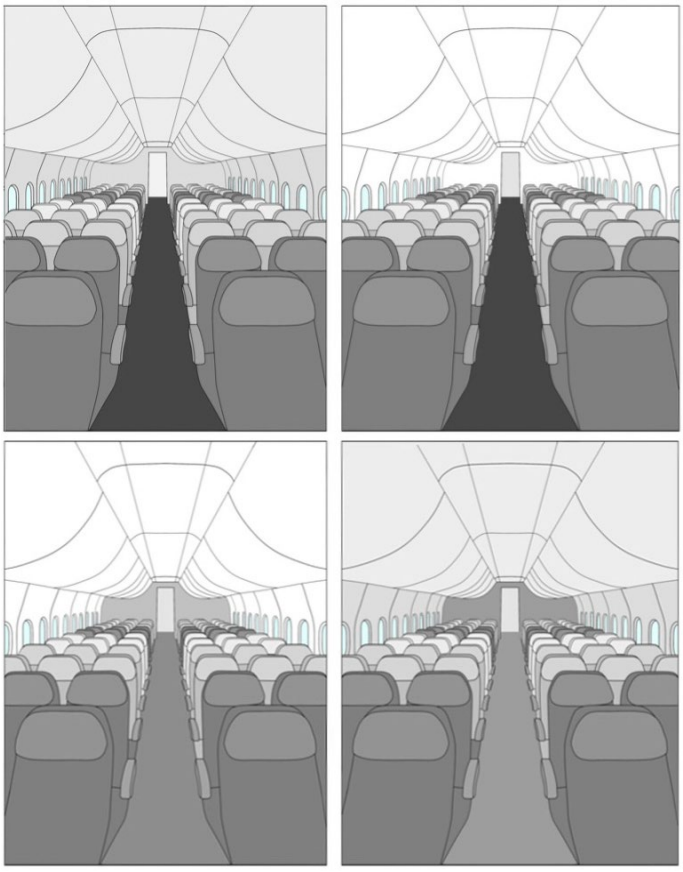

Fig. 6. Gestalt perception of possible color combinations for the cabin space.

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. 7):

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";

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 6.

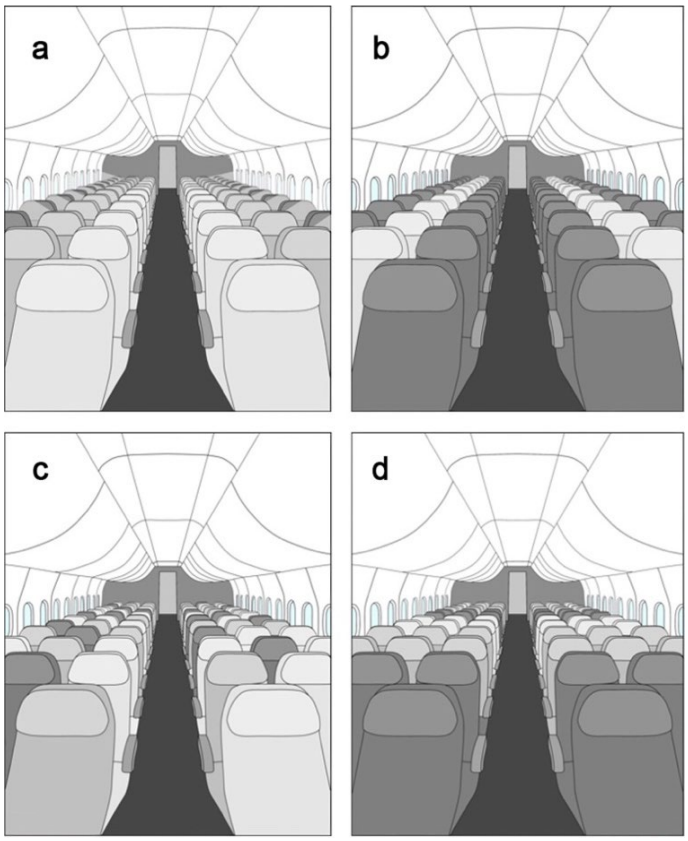

Fig. 7. Gestalt perception of possible color combinations of the seats.

4. 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. 8).

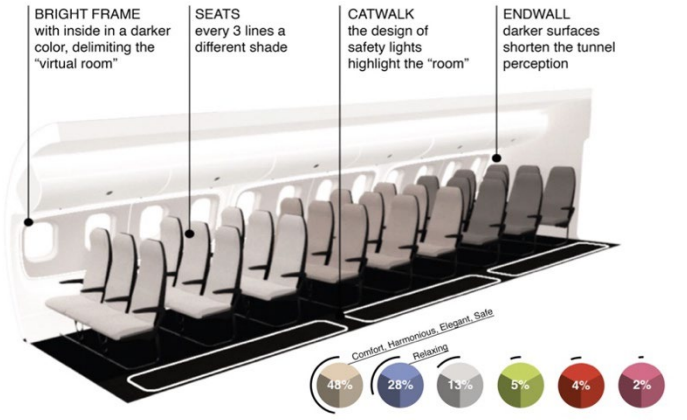

Fig. 8. Summary diagram of the elements characterizing the color in the cabin and the percentages of appreciation of the different shades.

5. 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 neutral color temperatures (4000K) 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. 9).

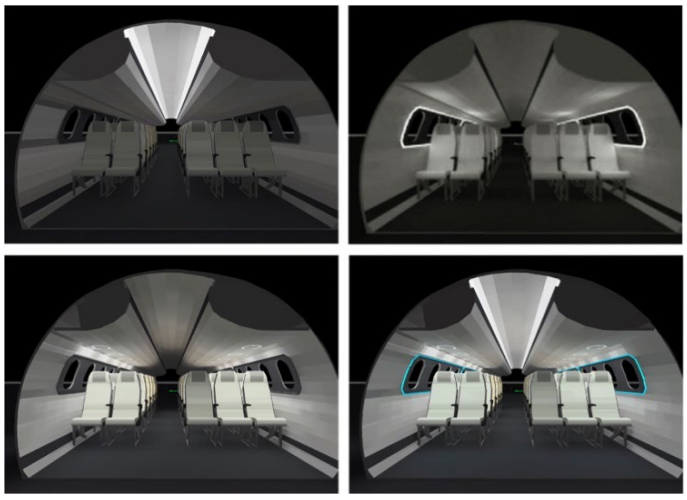

Fig. 9. The 3 types of ambient lighting fixtures active individually and (bottom right) the 3 types active simultaneously (Anna Pellegrino, Argun Paragamyan of DENERG Department – Politecnico di Torino).

6. Results and conclusions

In the near future, 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 related to accessibility and movement, airiness and lighting cabin, validity of the concept design in the definition in "virtual rooms" and related "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 a collaboration between the Department of Architecture and Design (DAD) and the Energy Department (DENERG) of Politecnico di Torino, 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. 10).

Fig. 10. 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.

7. Conflict of interest declaration

The authors of this paper declare that they do not have any actual or potential conflicts of interest, including financial, personal, or other relationships, with any other person or organization within three years of starting the submitted work. This paper is part of the work within the European research Horizon 2020 called CASTLE (CAbin Systems design Toward passenger wellLbEing) of which prof. Germak is coordinator for the Design section.

8. Funding source declaration

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9. Short biography of the author(s)

Stefano Gabbatore - PhD student in Management, Production and Design at the Politecnico di Torino. Member of UXD PoliTO team, with research field in physical and cognitive well-being within means of transport, analyzed through ergonomics and user experience tools.

Claudio Germak - Full professor of Design at Department of Architecture and Design (DAD) at Politecnico di Torino, and Member of Interdepartmental Center CARS@PoliTO - Center for Automotive Research and Sustainable Mobility. He also leads the UXD PoliTO team, actives in HCD/UX/UI methodologies for services/products evaluation and design. Past president of SID - Italian Design Society (2018-2021).

Notes

[1] Skytrax is a British research company operating in the field of civil aviation. It takes care of drawing up special dedicated rankings to airlines and airports. Carry out international surveys to identify the best airports, the most efficient airlines, the most qualified onboard and ground staff, the best quality onboard entertainment and catering and other crucial elements in a voyage airplane. Through these elements, Skytrax therefore wants to help the traveler choose the company that best suits their needs.

Licensing terms

References

Akkerman, S. and Vink, P. (2018) "Improving airplane boarding time by illumination guidance," *Advances in Intelligent Systems and Computing*, pp. 220–224. Available at: https://doi.org/10.1007/978-3-319-96071-5_23.

Ahmadpour, N., Robert, J.M. and Pownall, B. (2013) "The dynamics of passenger comfort experience: understanding the relationship between passenger and the aircraft cabin interior". *The International Conference of Canadian Aeronautics and Space Institute, CASI Aero*. Toronto.

Anceschi, G., Botta, M. and Garito, M.A. (2006) *L'Ambiente dell'apprendimento: Web design E Processi Cognitivi*. Milano: McGraw-Hill.

Bagassi, S., Lucchi, F. and Persiani, F. (2016) *Aircraft preliminary design: A windowless concept*, *IRIS*. Available at: https://cris.unibo.it/handle/11585/556081 (Accessed: February 7, 2023).

Bianco, V. (2018) *Volare a Colori: La percezione del colore in cabina come elemento influenzante il benessere Durante Il Volo.*, *Webthesis*. Available at: https://webthesis.biblio.polito.it/8290/

Bubb, H. *et al.* (2015) *Automobilergonomie*, *SpringerLink*. Springer Fachmedien Wiesbaden. Available at: https://link.springer.com/book/10.1007/978-3-8348-2297-0 (Accessed: February 7, 2023).

De Crescenzio, F. *et al.* (2019) "Human centred design and evaluation of cabin interiors for business jet aircraft in virtual reality," *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 13(2), pp. 761–772. Available at: https://doi.org/10.1007/s12008-019-00565-8.

de Jong, A.M. and Vink, P. (2005) "7 Reducing Discomfort in Installation Work", *Comfort and design: principles and good practice*, pp. 85-93. CRC Press. IES (2018) *ANSI/IES TM-30-18 Method for Evaluating Light Source Color Rendition*. IES. Available at: https://www.ies.org/product/ies-method-for-evaluating-light-source-color-rendition/ (Accessed: 5 November 2018).

Di Salvo A., Germak C. (2019) "The extended comfort. Analysing the flight journey through a design-oriented approach", *XXV International Congress of AIDAA Italian Association of Aeronautics and Astronautics*, Roma, 9-12 September 2019, p. 935

Jaglarz, A. (2011) "Perception and illusion in interior design.", *International Conference on Universal Access in Human-Computer Interaction*, pp. 358-364. Springer, Berlin, Heidelberg. Available at: https://doi.org/10.1007/978-3-642-21666-4_39

Ong, B.L. (2013) *Beyond Environmental Comfort*. London: Routledge.

SkyTrax Report rating of the all-airplane companies in the world (2023). https://skytraxratings.com/a-z-of-airline-ratings

Torkashvand, G., Stephane, L. and Vink, P. (2019) "Aircraft Interior Design and satisfaction for different activities; a new approach toward understanding passenger experience," *International Journal of Aviation, Aeronautics, and Aerospace* [Preprint]. Available at: https://doi.org/10.15394/ijaaa.2019.1290.

Vink, P. and Hallbeck, S. (2012) "Editorial: Comfort and discomfort studies demonstrate the need for a new model," *Applied Ergonomics*, 43(2), pp. 271–276. Available at: https://doi.org/10.1016/j.apergo.2011.06.001.

Winzen, J., Albers, F. and Marggraf-Micheel, C. (2013) "The influence of coloured light in the aircraft cabin on Passenger thermal comfort," Lighting Research & Technology, 46(4), pp. 465–475. Available at: https://doi.org/10.1177/1477153513484028.

Yao, X., Song, Y. and Vink, P. (2021) "Exploring factors influencing visual comfort in an aircraft cabin.", 3rd International Comfort Congress 2021, Nottingham.

Zhang, L., Helander, M.G. and Drury, C.G. (1996) "Identifying factors of comfort and discomfort in sitting". Human factors, 38(3), pp.377-389. https://doi.org/10.1518%2F001872096778701962