

Article

Color as a Key Factor in Creating Sustainable Living Spaces for Seniors

Anna Jaglarz 

Faculty of Architecture, Wrocław University of Science and Technology, ul. Bolesława Prusa 53/55, 50-317 Wrocław, Poland; anna.jaglarz@pwr.edu.pl; Tel.: +48-667129009

Abstract: Color as a feature of interior spaces is a fundamental component of human interaction with the built environment. Therefore, planning the design concept of an interior space with attention to color choices is extremely important, especially when the users of a given space include individuals who require additional support and care, such as the elderly. The colors used in architecture and interiors play a crucial role in the well-being of older adults, influencing their spatial perception, behavior, and activity. With age, color perception changes due to the effects of the aging process on vision. Visual deficits lead to shifts in sensory perception, which can, in turn, affect the sense of well-being, often creating a heightened sense of uncertainty. These changes in color perception due to aging may impact the color preferences of older people within their living environments. To create supportive environments for seniors, it is necessary to investigate which colors are most easily recognized, which colors are easiest to distinguish, and which colors are preferred by older adults. Based on a review of the literature and research findings on age-related changes in chromatic and spatial perception, design recommendations and guidelines have been developed. To supplement this knowledge, a survey was conducted among seniors to gather insights on their color preferences. Observations and analyzes of the survey results point to strategies for color use and underscore the importance of color in designing sustainable living spaces for seniors.

Keywords: architecture; interior design; color theory; visual comfort; color preferences; color perception; design for seniors; sustainable living space; healthy aging



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1. Introduction

The design of an indoor built environment significantly influences the moods, behaviors, actions, productivity, and overall psychophysical condition of its users. A specific interior can have either a positive or negative impact on its inhabitants. Thus, it is important to examine factors that benefit users, particularly those with special needs, including the elderly. Older adults are especially sensitive to interior design features, especially when experiencing functional and sensory limitations, such as visual impairments. Adapting the physical environment to meet the unique needs of residents by improving visual comfort, orientation, and overall well-being can support their independence [1–4].

Color, as an essential feature of interior spaces, forms a foundation of human interaction with the built environment. Color plays roles in creating contrast, attracting attention, aiding identification, and helping users recognize and remember objects. It conveys messages, directs focus, and stimulates perception of the surrounding environment. Colors enhance spatial diversity, facilitate distinguishing elements, highlight zones, and establish a specific atmosphere and mood. They can also evoke a range of emotional responses [4–6].

Color is of paramount importance to the perception of beauty in the built environment. The need for beauty, its admiration, and appreciation is one of humanity's deepest desires. Beauty is an attribute of creativity that elicits positive emotions. It is often associated with a psychological response to certain characteristics, primarily visual ones. These qualities are closely related to the natural environment, including the worlds of plants and

animals. This concept also encompasses human creative activity, particularly in shaping the built environment, architecture, interiors, everyday objects, and art. Ensuring aesthetic experiences and fostering sensitivity and an appreciation for beauty are equally essential in later stages of life. Architects and interior designers have significant opportunities to meet these needs through their work [7].

The impact of colors on the environment and people has been known for a long time. The absence of colors leads to monotony and boredom in the perception of space. Therefore, careful planning of color choices in design is crucial, particularly when creating spaces for individuals who require additional support and care, including the elderly [2]. Monotony and lack of color stimuli in interiors can complicate spatial orientation by limiting the visual cues necessary for identifying architectural features. A monochromatic color scheme can reduce stimulation, excitement, and challenge for seniors, potentially contributing to apathy, illness, and even feelings of life dissatisfaction. Providing a thoughtfully designed, sustainable color environment can offer seniors greater comfort and improved visual accessibility. The effects of colors in interiors have a significant impact on the well-being of older users by stimulating and activating their “reserve capacities”. Colors influence spatial perception, behavior, decision-making, and overall engagement, improving the visibility of interior elements and enhancing both safety and quality of life for seniors [2,8–11].

One of the most prevalent challenges faced by older adults is visual sensitivity disorders, which alter environmental color perception. With age, color perception changes due to the physiological effects of aging on vision. These visual deficits lead to altered sensory perception, affecting well-being and often causing heightened uncertainty. The challenge may be more pronounced in environments not adapted to senior needs [1,3,12].

Designing spaces for the elderly must address these limitations to minimize spatial and functional difficulties. To understand how colors can alleviate spatial discomfort among older adults, it is essential to analyze the consequences of visual changes in their chromatic and spatial perception of the built environment. Research into the relationship between ambient colors in interior design and seniors’ visual comfort is necessary for creating spaces adapted to their needs [1].

Age-related changes in environmental color perception may influence seniors’ color preferences in their living spaces. This underscores the need to identify which colors are desired by the elderly and establish specific correlations among these preferences. Such insights can lead to actionable conclusions for defining color design guidelines. This research can contribute meaningfully to architectural and interior design practice.

The findings can inform chromatic strategies aimed at preventing or mitigating visual disturbances related to color perception, ensuring high levels of visual comfort during aging. Although the literature on visual aging and age-related eye conditions is well-developed, its application in architectural design, particularly regarding color guidelines for visual comfort, remains limited. The ambiguity in guidelines for effective color use in interiors often discourages bold color choices among designers [1,2].

The interior environment requires systematic analysis concerning color application [5]. Therefore, further research on the intricate relationships between color, the environment, and the mental and physical health of older adults is essential. Interdisciplinary collaboration involving representatives of different disciplines, including healthcare professionals, psychologists, as well as interior designers and architects, could yield solutions that minimize the adverse effects of aging-related visual changes on environmental color perception. In sustainable living spaces, aging can be more readily accommodated, supporting independence, health, well-being, and activity in daily life [1,2,8].

2. Materials and Methods

This study aims to verify the scientific hypothesis that color selection and combinations play a significant role in creating a sustainable living environment for seniors. The term “sustainable living space for seniors” is defined here as an environment that supports the health and well-being of elderly individuals, fostering both physical and mental well-being.

Such an environment should promote the independence and autonomy of seniors, provide visual comfort, reduce inconveniences associated with age-related visual impairments and eye conditions, improve perception and visual accessibility, and enhance the visibility of surroundings, element identification, and spatial orientation to ensure comfortable and safe daily functioning. Furthermore, a sustainable living environment should stimulate the physical and mental activity of seniors, helping to prevent apathy, depression, and other ailments, enabling them to remain socially active and avoid a sense of life fatigue. This environment should also offer aesthetic experiences, evoke positive emotions, and create a harmonious atmosphere around elderly individuals. The concept of “sustainable color schemes” encompasses color combinations that fulfill these needs, becoming an effective tool for designing senior-friendly living spaces.

To determine which colors may be most suitable for seniors, the study includes an analysis of sample color palettes created by experienced architects. The initial focus was on analyzing color palettes designed by Le Corbusier, which are considered exemplary in terms of color harmony. Next, a review of research findings related to the effects of the aging eye on chromatic and spatial perception was conducted, followed by an examination of a color palette that addresses these changes and served as the basis for interior design in a senior care facility. The comparison of analyzed color palettes revealed differences resulting not only from the hues themselves but also from the textures of the materials used. Consequently, a survey was conducted to examine the color preferences of seniors, aiming to determine whether they would choose palettes resembling those of Le Corbusier or rather those based on physiological research findings.

Based on a review of the literature, scientific articles, and research findings, the perception of colors among seniors has been analyzed. Visual perception changes with age, and sensitivity to certain colors may decrease. Common age-related visual challenges, such as reduced contrast sensitivity and difficulty in distinguishing detail and color, carry significant implications for design [1,13,14]. To understand how to use color to minimize spatial and functional difficulties among older adults, it is necessary to analyze the consequences of visual changes in their chromatic and spatial perception of the built environment. It is also essential to examine the impact of indoor environment colors on the visual comfort of seniors in order to adapt architecture to their needs [1].

The aging process alters environmental color perception, potentially influencing seniors’ color preferences for their living spaces [1–3]. Research is needed to determine which colors are most easily recognized, which are most distinguishable, and which are most desirable by older adults. It is important to observe the reaction to colors and the emotions evoked by colors, which can be associated with a sense of harmony or disharmony and can influence color preferences. Revealing these preferences can be crucial for creating comfortable environments. Insights from these observations can lead to the development of color-related design guidelines, supporting architects and interior designers in their professional practice [1,13]. Given the rapid growth of the elderly population, the demand for universally effective color schemes is also increasing [15].

Furthermore, examining the color preferences of seniors is essential, considering their aesthetic and color sensitivities, as well as their expectations for their immediate surroundings [16].

Previous studies on color perception, color effects, and color preferences, based on analyzing observers’ impressions, typically involve presenting a single interior with various color schemes, often using color filters as stimuli [10,11,17]. My method, however, utilizes diverse examples of residential interior concepts that are unique and individually designed, where color is thoughtfully selected and harmoniously integrated with other elements of the interior. This approach goes beyond presenting color as a mere distinguishing feature of a uniform model; instead, it situates color within the broader context of the atmosphere and mood created by the interplay of all interior elements. In this way, the observer’s attention is not solely focused on color; the chosen colors enhance the perception of the entire space’s ambiance.

To prepare the survey material, it was essential to study foundational color theories that support well-designed interiors. Le Corbusier's "color keyboard" from 1931, for instance, provided valuable insights. The color palettes he used in his iconic interior designs remain relevant today, with his adept use of color stemming from a keen observation of light within space. Le Corbusier's contributions to architectural development are widely recognized, and his "color keyboards" are still esteemed as symbols of quality and aesthetic sensitivity. The enduring presence of these colors in contemporary interior design elements reflects the ongoing influence of his color theory [18,19].

The literature review and theoretical framework underlying this study are presented in Sections 3–5 of this article.

3. Le Corbusier's Color Theory

Modernism brought forth notable color experts not only in the visual arts, such as painting, but also in architecture—a field commonly associated primarily with white and gray concrete. The most famous architect of this period, Le Corbusier, was an exceptional colorist, and his use of color has proven to be timeless. Contemporary color trends and currently used color palettes still reflect his "color keyboard" from 1931, originally created for the Swiss wallpaper manufacturer Salubra. Le Corbusier's Architectural Polychromy serves as a tool for designing architectural colors—a logically structured color system based on his "color concept" principles, which he began developing in the 1920s. His "color keyboard" was intended to inspire people to select harmonious colors for their interiors, offering a guide with 63 shades that he developed across two collections in 1931 and 1959.

The puristic palettes from 1931 include 43 shades across 14 series, consisting of solid colors and finely graduated tints. These shades are predominantly warm earthy tones—ochres, siennas, muted pinks, blues, grays, and greens. The second collection from 1959 complements the Architectural Polychrome with 20 additional colors that are more expressive and dynamic [18,20]. The introductory text to Salubra included a quote by Fernand Léger: *"Man needs colour to live; it's just as necessary an element as fire and water"*. Each of the 63 shades evokes unique spatial effects and distinct emotional reactions. Yet, they share one common quality: they are inspired by nature and coordinated to harmonize effortlessly, allowing them to be combined flexibly in various compositions.

Le Corbusier's color keyboards are not static prescriptions but rather sources of inspiration for achieving natural harmony in color choices. The architect wrote extensively on the effects of colors on space and its users, distinguishing colors that could optically alter a room's dimensions from those that serve as neutral tones. He attributed certain qualities to specific colors, including weight, depth, transparency, unity, and psychological impact, associating these traits with particular color groups. His palettes maintain harmony through similar tonal relationships and contrasts between warm and cool shades (Figure 1). Le Corbusier sought to shape spaces by manipulating color and light, encouraging the observation of natural light within interiors as a guide for selecting wall colors within the warm–cool spectrum.

He also initiated the concept of an "accent wall", a single wall set apart by a different color from the rest of the room to create contrast or dominance that enhances spatial dynamics. According to his observations, strategic color choices could discreetly obscure technical elements such as radiators or accentuate features like windows and doors. Thoughtful color combinations could thereby enhance the architectural composition of a space. [18,20] The reduced color palette was intended to avoid overwhelming the space, with the selection confined to 43 colors plus white, which serves as a background in a minimum proportion of 33–50%. More vibrant, high-chroma colors are limited to a proportion of 7.5–22% to maintain visual balance [21].

Le Corbusier also introduced other compositional principles in his color combinations. Colors were to clarify the distinct pure forms within a building and interior, highlighting their hierarchy. Solid colors were used consistently, with gradients rarely applied, and each architectural element was typically assigned a single color for its entire surface. The

architectural color was often selected based on associative connotations—colors were chosen to evoke specific ideas or feelings related to space [21]. This concept of “color association” remains underexplored in contemporary color research, despite evidence of strong associations between colors and specific concepts or emotions [22]. Le Corbusier classifies colors into three categories—constructive, dynamic, and neutral:

- **Constructive colors:** These are colors derived from natural pigments that contribute to a pleasant ambiance while subtly altering spatial perception. Often inspired by earthy tones, such as brown, ochre, and sienna, these colors foster a sense of harmony, warmth, and connection to the natural environment within architectural compositions. Constructive colors serve as a foundational palette, shaping the space’s overall atmosphere and character and include warm earth tones, cool blues, black, and white [18,23].
- **Dynamic colors:** Utilizing synthetic pigments, dynamic colors are employed to create high-contrast effects that evoke strong emotions. These bold, vibrant shades, such as saturated red, ultramarine, and yellow, consist of intense primary colors. Le Corbusier’s selective use of dynamic colors emphasizes focal points and visual elements that capture attention, instilling energy within architectural compositions. The inclusion of dynamic colors adds drama, dynamism, and visual intensity to a space [18,23].
- **Neutral colors:** Often referred to as transition or transparent colors, these shades incorporate translucent synthetic pigments, allowing for surface modifications without affecting perceived volume or spatial depth. Examples include soft earth tones, grays, and greens. Typically applied as glazes or translucent finishes, neutral colors subtly enhance texture and adjust the tonal quality of materials, enabling refined alterations in the architectural composition while preserving the overall spatial perception of the interior [18,23].

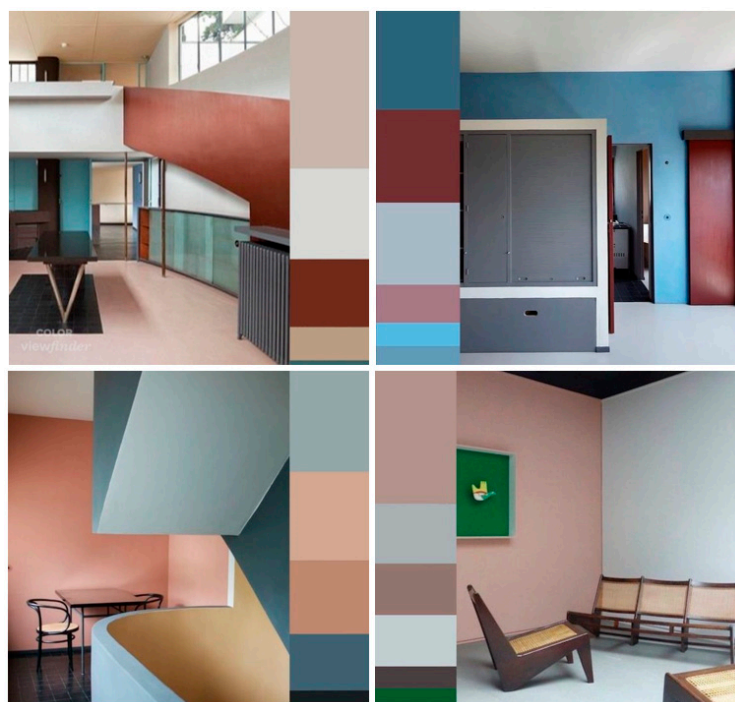


Figure 1. Le Corbusier’s Color Palettes, (source: courtesy of Barczak O.).

4. The Effects of Interior Colors on the Visual Comfort of the Elderly

The trend of an aging society presents significant challenges and requires solutions that enhance the well-being of older adults. A human-centered design approach is essential, emphasizing sustainable, inclusive, universal, and user-friendly principles. Prioritizing social integration and accessibility underscores the importance of addressing the needs and limitations of seniors, facilitating their active participation in social life. As people age,

they tend to spend more time indoors, which necessitates special attention to the quality of built environments [2].

Interior color choices are crucial for the visual comfort of the elderly, making it essential to design interior spaces with appropriate color solutions that support seniors' needs and promote independence, safety, and comfort. Research underscores the drawbacks of all-white architectural spaces, revealing that environments dominated by white surfaces often induce tension and stress. Monotonous, achromatic spaces negatively impact mental health by lacking visual stimulation and engagement [2,4]. High light reflectance from white-painted walls can cause eye strain, making vision difficult and creating distracting visual effects [24]. White-walled spaces can appear "empty" and "devoid of vitality" [25]. The monotony and lack of sensory stimuli in interiors can impede spatial orientation by reducing essential visual cues for identifying architectural elements [2].

Color, as a fundamental characteristic of interiors, plays a pivotal role in human interaction with the environment. It creates contrast, draws attention, and assists in object recognition and memory. Color conveys messages, focuses attention, and stimulates perception. For older adults, visual impairments can alter sensory perception, resulting in changes in well-being often linked to heightened uncertainty.

Understanding how color can be used to reduce spatial discomfort for seniors requires an analysis of the visual changes associated with aging and their impact on chromatic and spatial perception.

By examining the effects of aging on eyesight, we can address the following aspects:

- how seniors perceive colors and the factors influencing this perception;
- which types of changes in color vision are most challenging for older adults;
- what are the consequences of visual changes for the chromatic and spatial perception of the built environment;
- how these insights can inform design practices to mitigate the impact of visual challenges on seniors' daily functioning, thereby enhancing their overall quality of life.

4.1. *Changes in the Aging Eye and Their Effects on Color Vision*

4.1.1. Density of the Eye Lens

As the lens ages, its density and opacification increases. There is a decrease in the total transmission of visible light, especially after the age of 70. The transmission of visible light varies with age and is as follows: 95% in people of 30 years, 75% in people of 53 years, 31% in people of 75 years [1]. This change has a number of direct consequences for vision, such as:

- yellowing of the lens—at the age of 80, approximately 20% of older people may experience a significant yellowing effect of vision, which affects the perception of colors [1,12,26,27];
- absorption at short wavelengths—the dense, yellowish lens filters the shortest wavelengths of the visible spectrum, causing lower transmittance of the blue color range (as a result, the blue color range is not perceived well, leading to a change in color perception in this range) [1,12,26,27];
- ambient light and scattering effect—due to the density and opacity, lenses in older eyes cause greater scattering of light than in young people, which causes deterioration of visual acuity due to uncomfortable blurring of the field of vision and reduced color purity of the image (this problem is especially common in people with cataracts) [1,12,26,27].

4.1.2. Eye Pupil Size

Pupil size decreases with age and becomes less flexible. As a result, the eye admits less light. This fact causes a decrease in the intensity of retinal illuminance, especially in dark environments, which poses a risk to the elderly [1,12,26,27].

4.2. Changes in Color Vision and Their Consequences in Chromatic and Spatial Perception

4.2.1. Color Discrimination—Hue Sensitivity

As the eye ages, chromatic changes occur across the entire spectrum of visible light: hues from the red and yellow range are easier to distinguish, hues from the blue and green range are more difficult to distinguish. Due to the weakening of vision caused by aging, hues are perceived as more gray. To ensure accurate color perception, it is necessary to use higher saturation. It is also recommended to avoid certain color combinations that can cause confusion: white/yellow, purple/dark red, blue/green, dark blue/black, and purple/brown [1,12,26,27].

4.2.2. Color Discrimination—Sensitivity to Chromatic Contrast

With age, sensitivity to chromatic contrast decreases. This is why it is necessary to use noticeably higher levels of chromatic and achromatic contrast. There is also a need to create color combinations adapted to easy identification and differentiation through luminance contrast, the contrast between the object and the background. Clear color differences between a piece of equipment and its background improve the recognizability and definition of visual information. High contrast luminance/brightness color design, and contrast between object and background helps the elderly to navigate the built environment. Orientation becomes easier when, for example, door handles, handrails, and marking elements stand out from the wall in high contrast, making them noticeable even to people with visual impairments. It is recommended to use primary colors, which act as a code and provide a clue, because they are easier to recognize [1,12,26,27].

4.2.3. Color Discrimination—Color Desaturation (Low Color Saturation)

As the eye ages, a decrease in the clarity of an image or scene is noticeable. We can observe so-called image desaturation. The older eye perceives colors as less saturated. The perception of color saturation and image clarity depends on many factors, including the size of elements and the intensity of ambient light (smaller element—stronger desaturation effect, larger element—greater saturation effect, stronger light diffusion—stronger desaturation effect, stronger room lighting—greater saturation effect). To mitigate the effect of image desaturation, it is recommended to avoid combining colors with the same saturation or brightness level, because they are perceived as more similar and more grayish. Due to this, objects can be blurry and confusing. It is also necessary to consider the use of different types of contrasts depending on the color properties: chromatic/saturation contrast, brightness contrast, and hue contrast [1,12,26,27].

4.2.4. Color Discrimination—Range of Hues Corresponding to Short Wavelengths

The decrease in lens transmittance at short wavelengths significantly affects color visibility, which causes a loss of color discrimination, especially in the blue and green range. For this reason, the following combinations should be avoided: blue/gray, blue/green (e.g., blue on a gray or green background). It is recommended to take into account a high contrast of brightness when using blue and green hues. As we age, blue is perceived as more greenish and green as more yellowish. It is necessary to use color combinations taking into account this change [1,12,26,27].

4.2.5. Color Discrimination—Range of Hues Corresponding to Medium and/or Long Wavelengths

According to research results, colors in the red and yellow range are easier to distinguish. It is recommended to use colors corresponding to medium and/or long wavelengths—red, orange, yellow—to define details, objects, or spatial elements (Figure 2). Studies show that yellow is the color most easily recognized by people who are losing their sight. For this reason, yellow is recommended in public spaces dedicated to people with serious visual impairments (including the elderly) as a color that helps with orientation

and as a safety color. However, it is not preferred in home interiors, because long-term exposure to the yellow color can be tiring, irritating, and annoying [1,12,26–28].

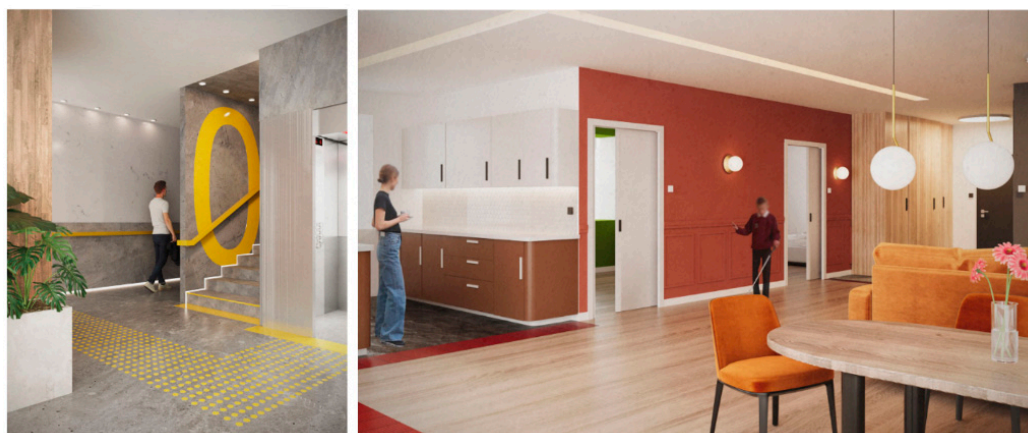


Figure 2. An example of using colors from the yellow, orange, and red range in the interiors of a multi-family building friendly to the blind and visually impaired, elaborated by Kozaczyńska K. (source: courtesy Kozaczyńska K.).

4.2.6. Sensitivity to Dark Environments and Glare Effect

The appearance of colors and their distinguishing depends on the intensity of ambient light—the perception of colors varies depending on the illuminance of surroundings and changes in lighting. As the eye ages, the number of rods (photoreceptors in the retina responsible for seeing in the dark) decreases. They also lose some of their sensitivity in visual function. This change causes an inefficient vision process in environments with a reduced level of light, as well as a slower adaptation process of the eye in a darker space. For this reason, it is recommended to use higher lighting levels. However, luminance above the eye’s adaptation level should not be used to avoid glare. Dark colors should be avoided as they increase the impression of darkness and create a “closed” and “confined” effect in the room. In small spaces, lighter colors are recommended to increase the feeling of spaciousness and improve lighting conditions. Color combined with light can be used as a code and a clue to provide orientation [1,12,26,27].

4.2.7. Recognizability and Reaction Time

Reaction time to light and chromatic stimuli becomes slower with age (at the age of about 80 reaction speed changes significantly). Older people need more time to detect, distinguish, recognize, or identify objects and elements of the visual scene, among other things, due to changes in chromatic perception. Reaction speed is further reduced for combinations of blue and gray color stimuli. Applying colors with these changes in mind can make it easier to recognize and remember objects and images. Choosing the right colors can improve object identification in terms of accuracy and reaction time [1,12,26,27].

4.2.8. Visual Acuity

Visual acuity based on depth perception and focus, as well as sensitivity to spatial contrast, begins to decline significantly after the age of 70. The deficits in spatial vision sensitivity in older people are largely due to the characteristics of color vision. Despite the adaptation of the person who does not perceive many of these gradual changes, the ability to distinguish colors and maintain control over the built environment becomes increasingly difficult with age in some circumstances. Objects without a fixed and well-defined shape are more difficult to distinguish compared to objects with a clearly defined form. The use of high color contrast and clear chromaticity can improve the identification of object locations and thus contribute to better spatial understanding and orientation. The right choice of colors can ensure that individual elements in a space can be easily distinguished. Interior

spaces and different surfaces can be defined by the most recognizable colors (e.g., primary colors) [1,12,26,27].

4.3. Design Recommendations and Guidelines

Based on the literature review and analysis of research findings, we can offer some general recommendations and design guidelines. They are primarily grounded in observations of physiological changes in vision associated with aging. Key recommendations include the following:

- Chromatic monotony and lack of color stimuli in interiors may make orientation difficult for older users due to the lack of visual cues needed to identify architectural features [1,2,4].
- Color monotony results in a lack of stimulation, excitement, and challenge for seniors, which can inhibit their potential and lead to apathy, illness, and even a sense of weariness with life. It is essential to create a color environment that can stimulate and activate the “reserve capacities” of the elderly [4].
- Elements of equipment that may pose a safety risk to seniors should be designed using contrasting colors. Contrasting colors enhance cognitive stimulation and orientation [29].
- Stronger contrasts (3.5% higher than for people aged 20 to 30) positively impact the vision of older adults. This is especially important regarding the “figure–ground difference” when viewing an object within its immediate surroundings. Objects are easier to recognize when there is a clear contrast between them and their background [4].
- Cool tones, such as blue and green, may appear grayish to aging eyes. Therefore, it is recommended to avoid blue–green or blue–grey combinations, or to pair them with complementary colors from the warm spectrum. Shades of violet, blue, and green tend to look more pale or grayish, so when using these colors, it is advisable to select more intense hues [1,4].
- Warm colors are most easily perceived by seniors. Friendly, calming, warm hues have a vitalizing and energizing effect. Wood is also generally perceived as a warm color [2].
- Interior colors should be adapted to functional areas to create the right atmosphere, personalize the space, and enhance memory and orientation. Colors appropriately matched to individual zones within the home can support spatial orientation [2,3].
- Due to the impaired spatial perception and depth perception of older adults (making it difficult to distinguish between background and foreground objects), the use of expressive, dynamic, contrasting patterns should be avoided, especially on floors and stairs. For this reason, floor coverings with large, bold patterns should not be used on stairs, as they can make it difficult to perceive the height and depth of each step [4].
- Glare sensitivity increases with age, which reduces contrast perception. Therefore, it is recommended to avoid shiny surfaces and to use matte finishes on floors to prevent reflections and the appearance of a slippery surface. Smooth, glossy floors can appear slippery and may cause older adults to fear falling [4].
- An excess of colors can overstimulate the sensory perception of seniors. Therefore, it is important to create harmonious color palettes. A safe and effective approach is to use colors found in nature or derived from the natural qualities of materials [30].

5. Importance of Multidisciplinary Approach to Color Design for Seniors

Design guidelines based on changes in chromatic perception due to age-related visual impairments are valuable, but do not clearly address which colors should be used in the built environment to ensure seniors’ well-being. When designing sustainable living spaces for seniors, it is essential to consider not only their specific needs resulting from physiological limitations in color vision and discrimination, but also their expectations and preferences related to color. Recognizing that color choice can be highly individual, influenced by tendencies, associations, tastes, and aesthetic sensitivity, we should adopt a

broader perspective on the role of color in interior design. Creating a sustainable, satisfying living space for seniors, with color as a key tool, requires a multidisciplinary approach.

Today, we see a growing connection between human-centered ergonomic design and fields such as ecological psychology, environmental psychology, and neuroscience in architecture. This approach emphasizes the psychosocial aspects of design and the impact of environments on individuals, their health, and well-being [2,4]. One of the most fundamental needs of aging individuals is to live independently in their own home for as long as possible. They desire independence, self-reliance, and an active lifestyle [2]. When developing strategies to enhance seniors' quality of life in their homes, it is essential to create stimulating environments that are activating and exciting. Such spaces, incorporating features like colors, can stimulate the body's "reserve capacities," making it more energetic and autonomous than in low-stimulation settings. Often, these "reserve capacities" are overlooked, particularly in environments that lack stimulation, such as some senior care homes, which can inhibit residents' potential and contribute to apathy, illness, and even feelings of life-weariness [4].

Seniors, consistent with their individual lifestyles, also need calm and privacy alongside opportunities for social engagement. To create safe and comfortable living spaces for seniors, their needs for quiet, intimacy, and personal reflection must be balanced with opportunities for activity and connection.


Aging naturally brings physical changes, such as a decline in vision, memory, and orientation. Sensory deficits can lead to changes in perception and a decreased sense of well-being, often accompanied by uncertainty. Effective design of living spaces should address these challenges to compensate for sensory and perceptual limitations as much as possible [1,2,4]. The fundamental needs of older adults relate to their altered sensitivity to external stimuli and its psychological effects, which are often linked to physical limitations. Impairment of the sensory organs and central sensory processing makes external compensation essential.

Memories are also crucial for older adults and form a foundation for their emotional well-being. This creates a need to stimulate memory, which can be encouraged by including familiar items, such as favorite furniture, decorations, paintings, clocks, photos, mementos, artworks, and other personal items in the seniors' environment. These personalized elements can stimulate memory, fostering a feeling of familiarity and rootedness in their living space. Older adults also have a fundamental need for a sense of existential well-being and connection, as well as a desire for warmth, calm, security, and protection from fear and disruption. Additionally, it is important to consider individual needs for stimulation, participation, intellectual activity, memory support, as well as privacy, intimacy, calm, relaxation, and space for reflection [4].

The living spaces of the elderly should convey an atmosphere of warmth, security, calm, and comfort. They should also provide invigorating stimulation and a variety of experiences. They should not express uniformity or monotony, but have a friendly, safe and lively character, also in terms of colors. Friendly, calm, but not too cold color combinations would be the perfect solution. It is important to note that in older adults the sense of touch is often less stimulated than other senses. It can be activated by consciously selecting materials for their tactile sensations. The spatial environment should be designed to express a friendly and stimulating atmosphere, using mainly warm nuances contrasting with accents of cool color elements. Subdued color tones are recommended for rooms intended for relaxation and rest, e.g., bedrooms, while in rooms of activity, e.g., living rooms, a more stimulating and communicative atmosphere is needed [2,10]. This effect can be achieved by using bright, warm hues, saturated nuances, and contrasting accents. According to research, people with Alzheimer's disease are sensitive to touch and smell. In addition to scents and various natural materials, soft, pastel colors such as dusty pink or apricot are preferred, which are not too "flashy" or contrasting. It is recommended to use subtly stimulating colors that affect the senses. Table 1 presents an example of a

color palette that was designed for seniors in a care home taking into account the above guidelines [4].

Table 1. An example of the color palette for a care home designed by architects Otto Steidle and Gerhard Meerwein (based on Ref. [4]).

	Browns
	– Cool, muted, medium brown of wood
	– Brown–pink, pastel shade of wood
	– Warm brown of textured stucco
	– Brown–yellow string fabric with a distinct weave texture (a melange of colors: brown, yellow, orange)
	– Brown–gray upholstery fabric with a distinct warp and weft weave texture (with a predominance of brown)
	Reds
	– Burgundy shade of grained leather
	– Brick orange–red of textured stucco
	– Vermilion red (textured stucco)
	Yellows
	– Straw yellow of wood
	– Mustard yellow of grainy leather
	Greens
	– Very light jasmine green of textured stucco
	– Pistachio green of fabric
	– Emerald green of fabric
	Pinks
	– Light powder shade of pink (smooth stucco)
	– Melange of light powder pink with a subtle warm brown nuance (string fabric with a distinct weave)
	Grays
	– Gray–brown upholstery fabric with a distinct warp and weft weave texture (with a predominance of gray)
	– Silver gray with a satin sheen of brushed metal

The interior should use natural materials and facilitate contact with nature [4]. People's preference for natural materials stems from their attachment to natural environments. This makes it easy to recognize and perceive natural materials, which is especially important for older people. Natural materials and biophilic elements, e.g., wood, regenerate the nervous system, reduce stress, and add energy. Wood also has tactile, olfactory, and acoustic qualities. The color of wood also plays an important role in interiors. The arrangement of space can make its texture more noticeable or soften it by treating it as one of the shades. The color of the wood corresponds to shades from light beige to dark brown, and brown with the presence of yellow, orange, and red saturation, which corresponds to hues from the medium and/or long wave spectrum, more easily recognized and distinguished by seniors. In addition to its visual qualities, wood is a noble, durable and timeless material. It is one of the most friendly materials for shaping spaces for the elderly [2].

6. Overview of the Survey, Results, and Discussion

To complement the recommendations and guidelines for color design based on evidence regarding physiological changes in the vision of seniors, a survey was conducted to examine color preferences among this social group. For this purpose, 20 examples of living room interior designs were presented. These were visualizations made by students

as part of an “Interior Design” course. The designs differed in style and color. The design process was supported by in-depth theoretical and professional knowledge of interior design, including color theory and its effective use in living spaces. The study involved 90 seniors (57 women and 33 men), aged 65 to 95 (the average age of respondents was 75.6 years). The survey was conducted in Poland from August to October 2024 among culturally homogenous participants; therefore, cultural differences in color perception and preferences were not considered in this study. The study was conducted in-person, because a significant proportion of older adults do not use or have no access to the Internet. For this reason, the collected data can be considered particularly valuable. Table 2 contains 20 examples of color concepts for living spaces shown to seniors during the study. During the survey, each of the interior examples was presented as a printout on a separate sheet of paper, on a scale that allowed observers to familiarize themselves with all the concepts in detail. Each person was asked to choose only one of twenty different interior concepts that they considered the most friendly in terms of color. Table 3 presents a summary of the survey results.

The second part of the study concerned the choice of a favorite color. This order of conducting the two parts of the study was intentional. The choice of a favorite color was preceded by appropriate visual stimulation of seniors, resulting from earlier viewing of interior concepts in different colors.

- Interior 1—living room arrangement designed in various shades of grey. It is a monochromatic composition, without color accents and contrasts. None of the surveyed seniors decided to choose this interior concept.
- Interior 2—a room arrangement in warm colors—beige, brown, orange, and brick red, with elements in gray. This color composition was chosen by one older adult.
- Interior 3—a composition of light grays, cool beiges, and a distinct, saturated sea green on an accent wall. Wooden elements in a shade of light, warm brown are an addition. This concept was chosen by two seniors.
- Interior 4—arrangement of the room in a very warm tone resulting from the combination of yellows, oranges, reds, and light warm browns. The composition is complemented by light pea green. This interior was chosen by two older adults.
- Interior 5—an example of a living space in cool colors. It is a composition of warm off-white, light cool beige, muted purple, mint green, and gray. It also features a black ceiling surface, cool white light, and fine black elements. This concept was chosen by two seniors.
- Interior 6—color composition based on cool white, gray, silver, black, and muted navy blue with accents of old gold. This interior was chosen by three older adults.
- Interior 7—bright interior, the colors of which result from a combination of white, light turquoise blue, and cool yellow. The whole composition is complemented by copper and black accents and the beige of natural wood. This proposal was chosen by three seniors.
- Interior 8—interior design based on brown shades of natural wood combined with cool and warm white. The color combination is complemented by bluish gray and cool dark brown. This concept was chosen by three seniors.
- Interior 9—the colors of this living space are a combination of muted shades of indigo, gray, honey brown wood, and red brick. The composition is enriched with elements in different shades of white and fine accessories in black. This interior was chosen by four older people, with a predominance of men.
- Interior 10—an example of an interior in cool colors. It is a composition of light grays, cool shades of brown, and the beige of natural wood. The color combination is complemented by white and black elements. This proposal was chosen by four older adults.
- Interior 11—arrangement of the day zone based on a combination of white, gray, straw shade of wood, and light green “khaki”. The composition is complemented by anthracite and black elements. This interior was chosen by four seniors.

- Interior 12—living space, the color scheme of which is a composition of different shades of white, cool beige, gray, honey wood, forest green, and black. The combination is complemented by a nuance of ochre and gold. This concept was chosen by five older adults, mostly men.
- Interior 13—living space in warm tones resulting from the interpenetration of different shades of yellow, warm beige, gold, light and dark brown, rusty red, turquoise, and forest green. This composition was chosen by five seniors.
- Interior 14—interior design composition dominated by light blues, whites, and grays combined with the dynamic Indian Pink of the sofa and elements in mint green and honey brown wood. Wood also appears here in a dark brown shade. This proposal was chosen by five older adults.
- Interior 15—living space, the colors of which are created by shades of white, various grays, and light and dark blues. The composition is complemented by green, brown, and a nuance of honey leather. This interior was chosen by six seniors (including three women and three men).
- Interior 16—the color scheme of this living space is based on a combination of warm and cold white, light beige, ecru, forest green, gray, and brown. The composition is complemented by forest green and a nuance of turquoise and yellow. This interior was chosen by six older adults.
- Interior 17—living space, where constructive colors appear, such as shades of gray, beige, warm reddish wood, and golden-brown wood. The bright emerald green of the curtains is a dynamic color here. The composition is complemented by milky white, smoked glass, and shiny steel nuances as neutral–transitional colors. This composition was chosen by seven seniors (including three women and four men).
- Interior 18—interior design, based on a combination of warm white, pearl white, light beige, light brown wood, light pea green, and warm banana yellow. This interior was chosen by eight seniors.
- Interior 19—living room, where the composition is constructed by earthy colors—beige, ecru, light and dark browns, burgundy, and black. This color combination is complemented by milky, muted white, mint green, and red hue as a dynamic color. This composition was chosen by nine seniors.
- Interior 20—interior design, in which shades of white complement each other—cool, warm, white of natural wool, creamy, and ecru. Light beiges and browns of natural wood also appear here. Light, bluish, and almost anthracite greys are both matte and shimmering with a copper shade. We can find a small addition of black here. Different shades of green come from nature and plants. The warm nut brown of the armchair appears as an accent. The interpenetration of the interior with the exterior provides an additional feast of colors. This composition was liked the most and was chosen by 11 seniors.

Based on the results of this study, we can observe that interiors with monochromatic, monotonous color compositions were not chosen by seniors, which may indicate that older people perceive them as sad and depressing, and at the same time unstimulating and uninspiring. Seniors do not want to live in such interiors because they lack colors, accents, and contrasts. Interiors dominated by distinctly warm or distinctly cold tones were also not popular. Likewise, seniors did not choose interiors with strong tonal contrasts or clear contrasts of saturation and brightness. They preferred harmoniously composed spaces, based on colors of similar tones, which emphasize each other through contrasts of warm and cold shades (which is in line with Le Corbusier's color theory). Such color compositions can be created based on the principle of shade similarity, i.e., selecting different colors that have the same intensity and a similar degree of chromaticity or brightness [31]. The greatest interest was aroused by compositions with colors coming from nature, the colors of the earth, and the colors of natural materials: wood, wool, natural fabrics, leather, and various shades of greenery. This means that seniors prefer a color environment that is associated with nature.

Table 2. Examples of color concepts for living spaces shown to seniors during the study.

1		2		3	
4		5		6	
7		8		9	
10		11		12	
13		14		15	
16		17		18	
19		20			

Table 3. Summary of survey results.




Concept No.	Total Preferences (90)	Women's Preferences (57)	Men's Preferences (33)
1	0	0	0
2	1	1	0
3	2	1	1
4	2	0	2
5	2	1	1
6	3	2	1
7	3	1	2
8	3	3	0
9	4	1	3
10	4	3	1
11	4	3	1
12	5	1	4
13	5	4	1
14	5	4	1
15	6	3	3
16	6	6	0
17	7	3	4
18	8	5	3
19	9	6	3
20	11	9	2

The clear preferences of older adults towards colors coming from nature are also confirmed by the results of the second part of the study, in which seniors indicated their favorite colors. A total of 57 out of 90 seniors chose colors from the range of shades corresponding to short wavelengths—blues and greens. Although research results confirm the weakening of the visibility of these hues due to the reduced transmittance of the lens at short wavelengths and the limited ability to distinguish them, shades of blue turned out to be the colors most liked by seniors. Shades of blue were chosen by 26 seniors as their favorite colors. Other preferred colors are greens, grays, and browns. The selected colors are the most important hues that we know from the natural world. These hues predominate in the natural landscape, which is why we have the closest contact with them. They can also be considered neutral colors because they complement each other, and their effect is balanced. Eyesight focused on these colors does not get tired. They have a calming impact. Among the cool colors that turned out to be the least liked by seniors was the color purple—only one person chose it. A total of 33 people chose colors from the range of shades corresponding to medium and/or long wavelengths. Although research results confirm that hues in the red and yellow range are easier for seniors to distinguish, these colors turned out to be less preferred by them than shades of blue and green. Only two people chose yellow, and only six people chose pure, saturated red. In the group of favored warm colors, many earth hues appeared—warm browns, ochres, siennas, rusty reds, and oranges. This choice once again confirms the clear inclination of seniors towards colors associated with nature. Interestingly, seven people, including three men, chose pink. As for achromatic colors—grey was selected by eight people, black by one person, and white also by one person. The results of the study are evidence of the lack of acceptance by seniors of achromatic or monochromatic surroundings. A living space devoid of colors is far from

the natural human environment in which there is wealth, diversity, and an innumerable number of shades.

A color palette was developed based on the interior concept most preferred by seniors and was compared with Le Corbusier's color palettes and the palette used in the interiors of a senior care facility, as presented in Table 4.

Table 4. Comparative overview of color palettes.

Color Palette Preferred by Contemporary Seniors	Color Palette for a Care Home	Le Corbusier's Color Palettes
		

The results indicate that the color preferences of contemporary seniors are more closely aligned with Le Corbusier's palettes. This similarity is evident in hue, saturation, and brightness, with a marked dominance of natural earthy tones, such as various shades of gray, beige, brown, muted blues, greens, ochre, sienna, off-white, and black. These palettes notably exclude very warm colors—red, orange, and yellow—which are predominant in the palette based on studies that suggest better perception of such colors. This preference can also be related to Le Corbusier's color theory, which categorizes colors into constructive, dynamic, and neutral groups. In a modern interpretation, constructive colors remain rooted in natural materials and pigments, reflecting earthy tones. These colors establish a foundational palette that contributes to the overall ambiance and character of a space, imparting a sense of harmony, warmth, and coziness. In the chosen composition, constructive colors include shades of cool and warm whites, natural wool whites, and ecru, along with light beiges and browns. Soft grays, bluish grays, and nearly anthracite tones appear in both matte and copper-tinted finishes, with a subtle touch of black also present. Notably absent are dynamic colors, as defined in Le Corbusier's theory, which emphasizes bold, saturated, and intense hues. Instead, the visual dynamism and spatial variability in this composition arise from a diverse array of materials, textures, lusters, reflections, and transparencies. This rich diversity and chromatic depth stem from the extensive range of tones available in modern finish materials, as well as from the capabilities of contemporary lighting solutions, which allow for varied illumination effects. Various shades of green derive from nature, specifically from plants. These can be classified as neutral colors, as they maintain a cohesive perception of a space. The integration of interior and exterior environments introduces an additional spectrum of neutral tones, reinforcing a connection to the natural world within architectural compositions. This enhances vitality and energy for the occupants—an effect that was unattainable in Le Corbusier's time due to the smaller window sizes available. Contemporary approaches to the design of built environments now enable the incorporation of natural environmental colors in ways that make them seem integral to both architecture and interiors [32].

The color preferences of seniors highlight the fundamental importance of ecological, natural earth tones in shaping sustainable living spaces, underscoring the need to incorporate these colors into biophilic concepts of healing architecture.

7. Conclusions

Color perception changes with age. Understanding the effects of aging on vision and chromatic perception is necessary to find out how older adults perceive their surroundings. The way of designing space with seniors in mind must take into account their imperfections in this respect in order to minimize spatial and functional difficulties. In order to adapt architecture to these needs, it is necessary to study the relationship between ambient colors and the visual comfort of seniors. It is worth emphasizing the importance of expanding knowledge on this subject from the point of view of various disciplines. Research should focus on using this knowledge in chromatic interventions to prevent or reduce color vision disorders and thus maintain a high level of visual comfort during the aging process.

In order to provide seniors with visual comfort and a sustainable living space, it is also necessary to take into account their color preferences, tastes, and aesthetic expectations, which are diverse despite similar visual changes and similar consequences of these changes in chromatic and spatial perception. Additionally, there are elements that support and complement color solutions. These are factors that improve the effectiveness of colors, such as: large windows, the interpenetration of the interior with the exterior, an aesthetic view outside the window, diverse greenery, efficient lighting, brightness, spaciousness.

In modern architectural schools, education on the proper selection of color in architecture and interior design and its role in ensuring visual efficiency and comfort is neglected [33]. By introducing this knowledge into design practice and applying the principles of ergonomic color design, we can improve the quality of life of people with visual impairments, especially the elderly, and ensure safe use of the built environment. The issue of the possibility of using the healing power of colors in the case of users with visual deficits and cognitive disorders is particularly important.

Demographic aging means that we need to understand the evolution of the living conditions of older adults, especially those vulnerable to loss of autonomy. Therefore, it is essential to know their needs in order to provide them with appropriate solutions. The discussed study attempted to analyze the significance of colors in the immediate surroundings of the elderly. The results underline the importance of color solutions for the well-being of seniors and indicate the important role of color in their daily lives. Chromatic intentions are recommended to generate a friendly and welcoming atmosphere, which is crucial to improving living conditions, ensuring a sustainable living space and environment, restoring autonomy, and active participation in social life. In addition, the issue of color in interior design represents the potential of non-pharmacological solutions to be a response to ailments other than those caused by aging eyesight or the appearance of cognitive disorders. Future research should explore the use of color in the care of people with terminal illness or in palliative care. Methods such as color therapy, light therapy, or art therapy can have a clear impact and a significant contribution to the design of healing architecture [34]. Colors also play an important role in biophilic concepts of housing and the surrounding environment, reinforcing the health, psychological, ecological, and social aspects of sustainable aging. The concept of biophilic design based on the innate human emotional affiliation with nature, in which we can find a myriad of colors resulting from its biodiversity, can provide a new perspective in the design and management of the living environment of elderly populations [35]. A comprehensive and kindly approach to supporting old age, based on the cooperation of humanities, social sciences, and engineering, may be even more effective with the participation of designers with increased sensitivity to colors [7]. Young people should be sensitized to these issues so that they can always respond to users with special needs and those requiring additional support.

When designing a sustainable living environment for seniors, it is recommended to consider the physical and psychological impact of colors on both the surroundings and the individuals. Designers should also strive for order, balance, and harmony in color combinations, drawing inspiration primarily from nature. Justifying the purpose and value of the conducted research, it is essential to emphasize the applicability of the results in the practical work of architects and interior designers, serving as design guidelines.

Additionally, these findings can be utilized in educational efforts as reference points for students and academic instructors in architectural design schools.

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