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THE ROLE OF COLOR AND CONTRAST IN SUPPORTING AGING VISION IN INTERIOR SPACES

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DEDICATION

So many people supported me during this journey, and I am deeply grateful to each of them.

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TERMS AND CONDITIONS

Aging Vision: The gradual decline in visual ability that occurs with age, including reduced contrast sensitivity, changes in color perception, and increased sensitivity to glare. This study focuses on these changes in adults aged 55 and older.

Color Contrast: The degree of visual difference between two adjacent surfaces, such as a door and a wall. High color contrast makes doors easier to identify, particularly for older adults with reduced contrast sensitivity.

Contrast Sensitivity: The ability to detect differences in lightness between adjacent surfaces. Contrast sensitivity declines significantly after age 60, making it harder for older adults to distinguish objects from their backgrounds.

Environmental Legibility: How easily a space can be read, understood, and navigated by its users. A legible environment has a clear layout and visual organization that allows people to locate destinations without confusion.

Hexadecimal Color Code (Hex Code): A six-character digital notation used to precisely define colors in design software (e.g., #1E3A5F for dark blue). Hex codes were used in this study to ensure exact color reproduction across all virtual conditions.

Inclusive Design: A design approach that creates environments usable by as many people as possible, regardless of age or ability, going beyond minimum accessibility compliance toward genuinely human-centered spaces.

Luminance Contrast: The measurable difference in lightness between two surfaces. It is considered the most reliable indicator of visual accessibility for older adults, as it reflects how easily one surface can be distinguished from another.

Mixed-Methods Research: A research approach that combines quantitative data (such as task times and survey ratings) with qualitative data (such as open-ended responses and thematic analysis) to provide a more complete picture of participant experience.

Presbyopia: An age-related condition in which the eye's lens gradually loses flexibility, affecting the ability to focus. It is part of a broader pattern of visual decline that also includes reduced contrast sensitivity and color discrimination.

Thematic Analysis: A qualitative method for identifying recurring patterns within a dataset. In this study, thematic analysis was used to analyze open-ended survey responses and participant comments about color, contrast, and comfort.

Thematic Saturation: The point in qualitative data collection at which no new themes emerge from additional responses, indicating the dataset is sufficient. Guest et al. (2006) suggest saturation can be reached with as few as 6–12 participants in focused studies.

Universal Design (UD): A framework for designing spaces and products that are accessible and usable by all people to the greatest extent possible. Universal Design principles provide the broader context for the recommendations made in this study.

Virtual Reality (VR): A computer-generated, three-dimensional environment experienced through a head-mounted display. VR was used in this study to present controlled interior conditions to all participants consistently, using the Meta Quest Pro headset.

Visual Clutter: The density of visual elements in an environment, such as furniture and decor. In this study, three clutter levels; high, moderate, and low were incorporated into the virtual model to examine how complexity affects comfort and navigation.

Wayfinding: The process by which people orient themselves and navigate through spaces. In interior design, wayfinding refers to design elements including color, contrast, layout, and lighting that help users locate destinations and move confidently through a space.

WCAG 2.1 (Web Content Accessibility Guidelines): An internationally recognized set of accessibility standards developed by the World Wide Web Consortium (W3C). WCAG contrast ratio formula is grounded in human visual perception and has been adopted in environmental and architectural research as a standardized method for measuring the luminance contrast between any two surfaces. WCAG defines three conformance levels: AA large (3:1 minimum), which applies to large-scale elements such as doors and signage; AA (4.5:1 minimum), the standard accessibility threshold; and AAA (7:1 minimum), the enhanced threshold representing the highest level of visual accessibility. In this study, the WCAG 2.1 relative luminance formula was used to calculate and compare the contrast ratios of the three door color conditions against the wall surface.

ABSTRACT

This study investigates how older adults' visual comfort, preferences, and navigation experience are affected by interior color and contrast tactics. As populations age, the physiological changes associated with aging vision, such as decreased contrast sensitivity and color discrimination, make thoughtful interior design more important for promoting independence, safety, and well-being. Few studies have specifically looked at how certain color and contrast choices affect older adults' subjective comfort and design preference in addition to their navigation ability, despite the growing body of research on aging vision and wayfinding.

The study used a mixed-methods approach, combining qualitative thematic analysis, post navigation surveys, and structured virtual reality navigation exercises. Using the Meta Quest Pro headset, ten participants, ages 57 to 80, selected through a public university's lifelong learning program, navigated a SketchUp-based virtual model of an internal corridor environment. Three door color conditions; blue, yellow, and green were selected based on their distinct positions on the visible light spectrum, their frequent appearance in healthcare and residential interior design guidelines, and their differential legibility under conditions of reduced contrast sensitivity documented in the aging vision literature. These three colors were tested across three different levels of visual clutter. In addition to completing four navigation tasks, participants answered 13 questions about comfort, color preferences, and ease of navigation in a post navigation survey.

The data revealed four themes. With zero navigation errors and the highest preference ratings throughout the entire study, blue was the most aesthetically pleasing and preferred door color. Yellow consistently produced visual confusion, resulting in all ten incorrect door approaches recorded during a specific task, a finding directly related to the physiological changes associated with aging reported in the literature. The majority of participants preferred a moderately cluttered setting, indicating that overall visual complexity influences comfort and ease of navigation in addition to color. Unfamiliarity with VR interfaces was identified as a contextual factor affecting navigation behavior and is explored as a methodological consideration for further study.

The findings provide evidence-based design guidance for interior designers, architects, and facility managers working in settings that support older adults, including prioritizing high-contrast saturated door colors against light wall surfaces, planning for moderate visual complexity over minimal clutter, and avoiding bright yellow in low-contrast wall environments. The study contributes participant-centered data to the field of inclusive interior design and lays the groundwork for more extensive sample sizes, a wider range of color conditions, and practical validation in the future.

Keywords: aging vision, color contrast, interior design, older adults, virtual reality, visual comfort, inclusive design, wayfinding

CHAPTER I: INTRODUCTION

As populations worldwide continue to age, the design of interior spaces must evolve to better accommodate the physiological changes associated with presbyopia and other age-related visual impairments (Liu & Wang, 2025). This necessitates a re-evaluation of established design principles, particularly concerning color and contrast, to optimize legibility, object recognition, and intuitive navigation for older adults (Pinheiro & da Silva, 2012a). One critical aspect of this design challenge is the role of color and contrast in facilitating wayfinding, which refers to the ability to navigate through physical spaces effectively.

Research indicates that diminished contrast sensitivity and color discrimination are prevalent among older adults, leading to difficulties in spatial navigation and increased risks of disorientation and falls (Pekel et al., 2014; Sia et al., 2013). These visual impairments are compounded by changes in cognitive processing, where effective wayfinding strategies may diminish over time, particularly in complex built environments (Pati et al., 2015a). This interaction between visual decline and cognitive change underscores the need for environments that provide clear, consistent, and supportive cues.

Specific design features, such as high contrast between surfaces and effective color schemes, can significantly aid older adults in orientation and navigation (Jiang & Verderber, 2017). For example, the use of contrasting colors on walls and signage enhances legibility and helps users distinguish between different areas and features in a building (Jamshidi et al., 2020). The psychological impact of color cannot be overstated, as colors can evoke emotions and facilitate memory retention, which is crucial for navigating unfamiliar environments (Costa et al., 2018a). Moreover, integrating visual cues, such as patterned flooring or artwork, can provide essential navigational aids by creating memorable reference points within a space (Jiang & Verderber, 2017).

To address the growing need for inclusive design, various design frameworks and guidelines have emerged. The Americans with Disabilities Act (ADA) provides essential standards to ensure accessibility in public spaces. However, it is increasingly recognized that adhering solely to ADA guidelines may not be sufficient to meet the diverse needs of all users, particularly those with age-related disabilities (Cross, 2020). Expanding upon ADA standards through Universal Design (UD) principles offers a more comprehensive approach to creating environments that are not only accessible but also adaptable to a wide variety of individual needs and preferences (Cross, 2020; Michopoulou et al., 2015).

UD encourages strategies such as high-contrast color schemes, clearly distinguishable pathways, and visually salient signage, which enhance orientation and wayfinding for older adults. Other guidelines, such as the WELL Building Standard and ISO 21542 (Accessibility and Usability of the Built Environment), emphasize human-centric design and environmental clarity, including visual cues for navigation, lighting, and color use (*WELL Building Standard*, n.d.)

Although these frameworks offer direction, there are still gaps in how they address the specific needs of older adults who are visually impaired. Beyond compliance, interior spaces can become effectively accessible by incorporating concepts from several guidelines, particularly those that emphasize color and contrast, to enhance legibility, spatial orientation, and safe navigation. By combining regulatory requirements with the flexibility of UD principles, designers can move beyond minimum compliance and create spaces that truly support independence, safety, and inclusivity for aging populations.

Beyond functional accessibility, the comfort and personal preferences of older adults play a significant role in how they experience and navigate interior environments. Research suggests that individuals are more likely to engage confidently with a space when its design elements feel visually familiar, legible, and non-overwhelming (Luo et al., 2024). Color palettes, contrast levels, and spatial arrangements that align with the sensory preferences of older adults can reduce cognitive load and promote a greater sense of ease during navigation. Designing with comfort and preference in mind therefore represents a meaningful extension of Universal Design principles, one that acknowledges not only physical accessibility but also the emotional and perceptual dimensions of how older adults interact with the built environment.

Research Problem

While prior research has explored aging vision, wayfinding, and accessibility independently, fewer studies have examined how specific color and contrast strategies in interior environments directly support older adults' navigation behavior and perceived comfort. Existing literature frequently relies on observational studies or clinical assessments, which, while valuable, may not fully capture the subjective experiences, preferences, and comfort levels that shape how older adults engage with interior environments during daily navigation.

Additionally, many studies focus on healthcare or institutional settings, leaving a gap in understanding how color and contrast function in more common interior environments such as educational or community-based spaces. There is also limited research that combines objective visual data with subjective user feedback to evaluate how older adults perceive and interact with interior design elements during navigation tasks.

This study addresses this gap by investigating how color and contrast strategies influence aging vision and wayfinding through the lens of participant comfort and design preference. By collecting structured participant feedback within a controlled virtual environment and supplementing this with a thorough review of existing guidelines, the research seeks to provide a more comprehensive understanding of how older adults perceive and respond to interior spaces and which design strategies most effectively support comfortable, confident navigation.

Research Goal, Objectives, and Research Questions

The objective of this study is to identify interior design strategies that support the changing visual needs of older adults. Specifically, it examines how the color of walls, floors, doors, furniture; the contrast between elements (such as wall–door or floor–wall transitions); and spatial layout contribute to environments that are safe, comprehensible, and easy to navigate. The study investigates these variables through a controlled virtual environment to determine how specific design features influence participant comfort, preferences, and wayfinding behavior for older adults.

The following research questions will be the focus of the study:

1. How do color and contrast strategies influence comfort and preference for older adults in interior environments?
2. Which specific applications of color and contrast (e.g., wall–door differentiation, floor–wall transitions) are most preferred by older adults in interior spaces?
3. How do spatial layout and visual cues interact with color and contrast to enhance the overall satisfaction of older adults in interior environments?

To answer the above-mentioned research questions, below are the key objectives of this study.

- Understand age-related visual challenges affecting wayfinding through a comprehensive literature review.
- Identify effective color, contrast, and visual design strategies that support navigation for older adults.
- Examine specific applications such as wall–door differentiation, floor–wall transitions for improving visual clarity.
- Evaluate participant comfort and design preferences using structured surveys administered during navigation tasks in a controlled virtual environment.
- Develop practical, evidence-based design recommendations that accommodate age-related visual changes.

Research Methodology

This study employed a mixed-methods, research-driven approach with an emphasis on participant comfort and design preference. The data collection methods were designed to examine how aging vision influences wayfinding by gathering structured feedback on color, contrast, and spatial variables within a controlled virtual environment.

Data Collection Methods

1. Literature Review

A comprehensive review of existing literature was conducted to establish a theoretical framework for the study. This review focused on research related to aging vision, wayfinding behavior, color and contrast perception, and inclusive interior design strategies for older adults.

2. Virtual Environment Design and Analysis

A controlled virtual interior environment was developed to simulate real-world navigation conditions while allowing for precise manipulation of visual variables. The virtual environment was designed to reflect common interior settings encountered by older adults and incorporated varying levels of color contrast and visual cues. This approach allowed for consistency across participants while minimizing external environmental variables that could affect navigation behavior.

3. Comfort and Preference Data Collection

Structured surveys and preference questionnaires were used to collect data on participants' comfort levels and design preferences during navigation tasks within the virtual environment. Participants were older adults aged between 55 and 85 years. Surveys were administered after each navigation scenario and captured ratings of visual clarity, ease of navigation, and comfort with specific design elements such as color contrast and spatial transitions. This method provided insight into which interior design strategies older adults find most supportive, intuitive, and comfortable during wayfinding.

4. Data Analysis

The collected survey data were analyzed to identify patterns related to participant comfort, design preferences, navigation ease, and interaction with color, contrast, and spatial cues. Findings were categorized based on comfort ratings, preference rankings, and qualitative feedback. These results were then compared with existing literature and design guidelines to evaluate alignment and identify opportunities for improving inclusive interior design strategies that support aging vision.

5. Ethical Considerations

All research procedures were conducted in accordance with ethical standards approved by the University of Oklahoma. Participant confidentiality was maintained throughout the study, and informed consent was obtained prior to data collection. No personally identifiable information was linked to survey responses, and all collected data were stored on secure, password-protected systems to ensure privacy and confidentiality.

This study primarily evaluates perceived navigation ease and visual comfort as the central outcomes, while performance measures (e.g., errors, task time) are used as supporting indicators. Preference is treated as a complementary subjective measure rather than a primary outcome.

Significance of the Study

This study is important because it highlights a crucial, yet frequently disregarded aspect of interior design: using color and contrast to improve aging vision. As the global population ages, older adults increasingly navigate through complex interior spaces, where poor visual differentiation can lead to disorientation, accidents, and reduced independence.

This study expands on traditional observational methodologies by incorporating structured comfort and preference surveys within a controlled virtual environment to provide nuanced, participant-centered insight into how older adults perceive and respond to interior spaces. By capturing self-reported comfort levels and design preferences, this approach makes it possible to identify which design elements promote ease of navigation, spatial clarity, and a sense of security, offering insights grounded in the lived experiences of older adult users.

The findings of this study provide evidence-based recommendations for applying color, contrast, and spatial cues to support aging vision, which has practical consequences for educators, architects, and interior designers. Additionally, the research contributes to the broader discourse on Universal Design by highlighting opportunities to move beyond minimum accessibility compliance toward more inclusive, human-centered interior environments. The ultimate goal of this research is to assist in the development of interior environments that foster dignity, safety, and independence for older adults in a variety of contexts.

Table 1: Research Questions and Measurement Framework

Research Question	Variable Addressed	Measurement Method	Data Type
RQ1: How do color and contrast strategies influence comfort and preference for older adults in interior environments?	Door color (blue, yellow, green); wall–door contrast level	Post-navigation survey ratings of visual comfort and ease of navigation; qualitative thematic analysis of open-ended responses	**Mixed**
RQ2: Which specific applications of color and contrast (e.g., wall–door	Wall–door differentiation; color saturation	Preference rankings and ratings from post-navigation survey	**Qualitative**

differentiation) are most preferred by older adults in interior spaces?			
RQ3: How do spatial layout and visual cues interact with color and contrast to enhance the overall satisfaction of older adults in interior environments?	Visual clutter level (low, moderate, high); spatial layout; color conditions	Navigation error count; task completion performance; survey comfort and satisfaction ratings	**Mixed**

Limitations of the Study

Despite its strengths, this study has a number of limitations. The sample size may be constrained by the time and practical limitations of participant recruitment and virtual environment-based data collection, which could impact the findings' relevance to the broader older adult population, particularly in consideration of differences in visual acuity, cognitive ability, and familiarity with digital environments.

Although the virtual environment allows precise control of visual variables such as color, contrast, and spatial layout, it may not fully replicate the richness of real-world interior settings. Certain sensory dimensions of real environments, such as lighting variation, physical depth perception, and ambient context, are difficult to fully reproduce virtually, and participant comfort responses may therefore differ somewhat from those elicited in actual spaces.

This study likewise focuses on visual design strategies, such as color, contrast, and visual signals, but does not examine other wayfinding factors like auditory cues, assistive devices, or social interactions. Additionally, the study's reliance on self-reported comfort and preference data may be subject to individual interpretation and response bias. These drawbacks point to areas for further exploration, including comparisons between virtual and real-world environments, the use of multisensory navigation techniques, and larger, more diverse samples. This study also serves as a pilot investigation, and future research is recommended to validate and expand upon these findings.

This study uses WCAG contrast ratio guidelines as a benchmark for evaluating color and contrast in the virtual environment. Although WCAG was designed for digital interfaces, it was applied here due to the lack of an established contrast standard specific to interior built environments. Future research would benefit from contrast guidelines developed specifically for physical spaces and aging vision.

Conclusion

This study investigates how color and contrast can help older adults navigate their way around interior spaces and support their aging vision. Interior design is essential for encouraging safe, clear, and confident movement since age-related visual changes affect how space is perceived and navigated. This study aims to determine design techniques that enhance visual clarity and spatial orientation for older users by concentrating on color application, contrast relationships, and visual cues.

Through structured participant surveys and preference assessments conducted within a controlled virtual environment, the study provides participant-centered insight into how older adults perceive and respond to interior spaces during navigation tasks. The results are intended to encourage the development of inclusive spaces that enhance older adults' independence, safety, and quality of life while also informing evidence-based interior design methods.

CHAPTER II: LITERATURE REVIEW

Color and Contrast in the Built Environment

Color and contrast are fundamental elements of human perception and interaction with the built environment. Color and contrast serve a variety of purposes in modern interior design that go well beyond aesthetics. Research in environmental psychology has established that color influences mood, emotion, behavior, and cognitive performance across diverse populations (Costa et al., 2018b). Contrast, which is the tangible shift in color or luminance that makes things distinct from one another, is the primary process by which the visual system organizes spatial information and distinguishes surrounding factors.

Color and contrast are effective design elements that influence how space is perceived, distinguish functional areas, convey information, and facilitate navigation in interior spaces. Researchers refer to these components as "environmental legibility", the ease with which people can comprehend and move around an area. Appropriate contrast levels and well-designed color schemes help minimize navigation errors, lower cognitive burden, and boost user confidence in new environments. On the other hand, inappropriate color selection and inadequate contrast can lead to visual confusion, raise stress levels, and jeopardize safety, especially for people who have cognitive or visual impairments.

As the world's population ages, the connection between color, contrast, and aging vision has emerged as a key area of study in interior design and environmental gerontology. To understand how design elements can drastically change older people's visual perception, comfort, and overall satisfaction with interior spaces, it is essential to examine the literature on how color and contrast support aging vision and influence the subjective experience of built environments.

As people age, they have problems concentrating, judging distances, and seeing details well. Therefore, improving clarity and making navigating easier require careful interior design.

Age-Related Visual Decline and Its Physiological Impact

Adults' ability to navigate spaces and perceive their surroundings is greatly impacted by age-related visual impairment, which is a complex issue. People's visual abilities typically decline with age, particularly their capacity to distinguish between colors and contrast; two critical abilities for spatial navigation. According to Sia et al. (2013), contrast sensitivity begins to decline around age 40 and drops dramatically around age 70. In their investigation of 231 people, the contrast sensitivity of the oldest group (71–85 years old) was 2-4 times worse than that of the 60–70-year-old group, particularly at high spatial frequencies. This decline occurs even in cases where normal eyesight is unaffected. The greatest drop in contrast sensitivity at all spatial frequencies was caused by posterior subcapsular cataract, and the decline with age was greatest in the highest spatial frequency (18cpd) and least in the lowest spatial frequency (3cpd) (Sia et al., 2013).

Similar findings have been reported across different populations. Nomura et al., (2003) documented comparable age-related changes in contrast sensitivity among Japanese adults, confirming that this decline is not limited to Western populations. The earlier research by Derefeldt et al. (1979) examined 33 normal observers in three age groups: young to middle-aged adults (20–40 years), older individuals (60–70 years), and youngsters (6–10 years) in order to establish important baseline findings. According to their findings, there are no appreciable changes in contrast sensitivity between the young and middle-aged groups, and it stays largely constant from childhood to middle age. However, a significant decline occurs after the age of

60, when people show considerably lower contrast sensitivity than younger subjects for most spatial frequencies greater than 4 cycles/degree. The observed pattern suggests that contrast sensitivity loss increases in later adulthood rather than occurring gradually throughout life. It mostly affects the middle and high frequency areas, which are important for determining edges and detail perception (Derefeldt et al., 1979).

The clinical importance of measuring contrast sensitivity in cases of visual disturbance has been well established. Arden (1978) displayed a practical clinical test of contrast sensitivity and results from a normal population, demonstrating the method's potential relevance in ophthalmology. According to recent study by Pelli and Bex (2013), contrast sensitivity determines the threshold between the visible and unnoticed, which has clear implications for basic and clinical vision science. They pointed out that although Fechner's 1860 review said that threshold contrast is 1% for an exceptionally broad range of targets and settings, computer testing has gained popularity due to its ability to evaluate threshold effectively and adaptively for a variety of stimuli.

Within the normal aging process, visual functions gradually decline; the quality of vision worsens, and color vision and contrast sensitivity are also affected. As people's needs change along with age, design should help people and communities and improve life quality in the present. Applying principles of visually accessible design and ergonomics, printed design objects, interior spaces, urban environments, products, signage, and all kinds of visual information will be effective and easier on everyone's eyes, not only for visually impaired people but also for all of us as we age. (Pinheiro & da Silva, 2012a).

Studies investigating the impacts of lens yellowing have provided significant information on how color perception varies with aging. Suzuki et al. (2005) measured response time, the number of nonresponses, response error, and subjective visibility evaluation for color Landolt-Cs presented to young and old adults (mean ages: 22.3 and 65.9 years, respectively) and to young adults wearing glasses with filters simulating an aging human crystalline lens. The results of older adult participants showed longer response time, higher nonresponse ratio, slower response speed, and lower visibility, particularly for gray and blue stimuli. Young subjects fitted with the filters showed tendencies similar to those of older adult participants, indicating that the yellowing of the human lens strongly influences the visibility of color targets in older adults. The correlation between subjective assessment and response speed fluctuates dramatically with age, indicating that assessing performance, including response speed, as well as subjective assessment is crucial for determining visibility and controllability in older adults (Suzuki et al., 2005).

Ishihara et al. (2001) noticed four color combinations that older adults find particularly difficult to distinguish: yellow/white, blue/green, dark blue/black, and purple/dark red. They discovered that at the age of 75, yellowing of the eyesight becomes more obvious using computer graphics that mimic age-related changes in vision. This simulation offers a practical tool for planning with the consequences of aging in real life in mind. The study underlined how important it is to carefully consider color schemes when creating interfaces for older users, such as switches, indicators, and displays (Ishihara et al., 2001).

Collectively, these studies establish color and contrast as fundamental components of environmental legibility and spatial perception. While their role in improving navigation and reducing cognitive load is well documented, the literature primarily emphasizes functional performance rather than how users subjectively experience these environments. This highlights the need to better understand comfort and preference as integral dimensions of interior design for aging populations.

Color and Contrast in Interior Design: Elements and Applications

Before delving into the specific impact of color and contrast in wayfinding for aging populations, it's important to recognize their broader benefits to interior design. Three main reasons explain how color affects interior spaces: physiological effects on circadian rhythms and eyesight, psychological effects on mood and emotion, and functional responsibilities in information exchange and spatial organization. In the practice of interior design, color is used on a variety of surfaces, such as walls, flooring, ceiling treatments, furniture, textiles, artwork, and architectural aspects. Every component adds to the overall spatial experience and visual hierarchy.

In interior spaces, contrast functions at multiple dimensions. On a larger scale, the contrast between the main surfaces, the walls, floors, and ceilings, creates spatial boundaries and affects how big a room is seen. At the intermediate level, object recognition and spatial navigation are impacted by background and furniture contrast. Legibility and usability are determined at a small scale by contrast in safety features, controls, and signage. These contrast levels work together to provide what designers refer to as "visual interest" while also fulfilling important functional needs.

Color and contrast are fundamental factors that impact navigating in complicated situations, especially for older adults and people suffering from cognitive impairments like dementia. For example, Pati et al. (2015b) highlighted the significance of particular design components that affect navigation, such lighting and signage, pointing out that high-contrast signage can greatly enhance orientation and lessen confusion in hospital environments. Their thorough investigation revealed that the main environmental components that support effective navigation include architectural distinction, interior design elements, signage, illumination, and spatial arrangement.

Overall, color and contrast serve both practical and visual functions in interior spaces, from huge room boundaries to little details such as signage and controls. The majority of studies concentrate on performance outcomes rather than how people truly feel in these settings, despite the fact that research indicates they aid people in finding their way and lessen confusion. This suggests that further research is needed to understand how color and contrast affect older persons' comfort and personal preferences rather than merely their ability to navigate.

Color Preferences, Visibility, and Safety in Aging Populations

The ability of older adults to navigate and feel safer in interior spaces is greatly enhanced by the thoughtful use of color. Creating surroundings that are supportive of older individuals requires an understanding of their color preferences and visual responses. Liu and Wang (2025) found that 108 older adult smartphone users strongly preferred warm colors, particularly orange (60.2%), and detested blue and purple. Older people preferred medium saturation (31.75–41.25%) and high brightness to reduce visual strain. This preference pattern is consistent with physiological changes in aging eyesight, where warm colors are still more easily recognized while short-wavelength (blue) light transmission is decreased due to lens yellowing.

Even for older adults with impaired cognitive function, high contrast red-black combinations doubled visibility rates (from 17.14% to 40%), according to Wang and Cho's (2022) eye-tracking study. This study investigated how older adults responded to color visibility in indoor residential settings. It found that participants focused more on doors with red color combinations (red-black and white-red) and stayed on the red-black combination for longer. In the same position, older individuals gazed at red-black doors more quickly than white ones, and they lingered on the red-black door longer than they did on the white door. Crucially, the gaze behaviors of the group with low cognition were less concentrated and noticeable than those of the group with normal cognition, according to the participants' MMSE (Mini-Mental State Examination) scores. It indicates that targeted color application partially offsets visual and cognitive decline, demonstrating that indoor color can increase the visibility of items that may affect older individuals' safety in their living spaces and improve their quality of life (Wang & Cho, 2022).

Beyond only identifying doors, color visibility has safety consequences. According to a survey conducted by Jaglarz (2024) among 90 Polish seniors (aged 65 to 95), they primarily preferred natural earth tones like whites, beiges, browns, and greens when designing cozy living environments. Blue was surprisingly the most favorite individual color (26 out of 90 persons), despite being physiologically more difficult to identify due to lens yellowing. This suggests that aesthetic and emotional requirements may take dominance over physiological conditions. This conclusion highlights the complexities of planning for aging populations. Hence, the solutions must combine physiological demands, psychological preferences, and cultural expectations. According to the study, interior space color is an essential element of how people engage with the built environment, and it has a significant impact on older adults' well-being by affecting their behavior, activity, and spatial perception (Jaglarz, 2024).

Liu et al. (2019) proposed color design techniques for the facade, indoor environment, and outdoor environment of aging institutions after analyzing the effects of color on the physiology and psychology of the old in the context of China's aging population. They pointed out that color design should consider both psychological requirements (such as a desire for comfortable, familiar colors) and physiological aspects of aging vision (such as a decreased sensitivity to blue light and contrast). It was to address the growing issue of aging and the growing need for facilities that are age-appropriate by using color design to create a comfortable living, entertaining, and service environment for older adults (Y. Liu et al., 2019).

Thus, research indicates that color preferences and visibility demand in older persons are influenced by both physiological changes and psychological or cultural influences. While high contrast combinations and warm colors tend to support better visibility and safety, studies also show that emotional and aesthetic preferences do not always align with what is physiologically easiest to see. This implies that successful color design for older adults needs to strike a balance between visual accessibility and individual comfort and preference, exactly the gap that this study seeks to fill.

Color and Contrast Strategies in Supporting Spatial Memory and Navigation

Min and Lee (2020) examined how contrast affects spatial memory in warm, cold, and neutral-colored environments by quantifying it in terms of architectural scale and the ability to recall furniture and architectural details. They found that color and contrast have a significant impact on encoding memories in their study of 114 participants who watched virtual simulation movies of residential studios. With a 17-percentage point difference (74% against 57%, $p<.001$), high contrast schemes enabled a much stronger recall of architectural aspects than low contrast schemes. Warm and neutral color schemes significantly improved participants' spatial recall (46%) compared to cool color schemes (36%). The color combinations showed no interaction effect between contrast and hue, indicating that color temperature and contrast function independently. These findings can be used to design color schemes for architectural areas that need improved spatial cognition and memory. This is especially crucial for older populations that may have memory problems (Min & Lee, 2020).

According to Marquardt (2011)who addresses the need for architectural designs to take into consideration the particular navigational requirements of people with dementia, contrasting colors can help with memory recall and movement guidance, making spatial navigation easier. Residents' spatial orientation and wayfinding are greatly impacted by a nursing home's floor plan design, but unfavorable architectural design cannot be entirely countered by other interventions such furnishings, lighting, signage, and color schemes (Marquardt, 2011).

Collectively, these studies demonstrate that people's ability to remember and navigate interior places is significantly influenced by color and contrast. Warm color schemes and high contrast have been demonstrated to enhance spatial recall, and contrasting colors can direct movement, especially for people with memory-related disorders. But the study also shows that inadequate spatial design cannot be entirely made up for by color and contrast alone. This highlights the necessity of looking at how these components interact with overall design and visual complexity to help older adults navigate interior spaces, which is the main goal of this study.

Wayfinding Systems and Spatial Cognition in Interior Environments

Moffat (2009) explained spatial navigation is a demanding cognitive skill required for everyday life in the environment. However, the majority of test batteries used to evaluate cognitive aging do not normally measure navigational skills. It is evident from empirical research that one area of cognitive function that is affected by aging is navigation. The hippocampus, Para hippocampal gyrus, posterior cingulate gyrus (retro splenial cortex), parietal lobes, and prefrontal cortex are among the key brain regions involved in age effects on navigation, according to the few functional and structural neuroimaging studies that address neurological correlates of these age-related differences (Moffat, 2009).

Using functional MRI, Hartley et al. (2003) conducted groundbreaking neuroimaging study that examined the brain underpinnings of route following vs wayfinding. They discovered that whereas competent navigators activated the head of caudate during route following and the anterior hippocampus during wayfinding, accurate wayfinding activated the right posterior hippocampus. These findings are consistent with neurophysiological evidence for separate place (hippocampal) and reaction (caudate) representations that facilitate navigation, indicating that the kind of representation employed affects performance as well as concurrent fMRI activity patterns (Hartley et al., 2003).

With all factors considered, these results demonstrate that spatial navigation is a complex cognitive ability that includes several different brain regions and deteriorates with age. According to research, the hippocampus and other brain areas have different functions in how humans learn and navigate. Interior spaces must be constructed to lessen the navigational demands on older adults as these cognitive capacities deteriorate with age. This validates the more general claim that careful application of color, contrast, and spatial arrangement can assist offset age-related impairments in spatial cognition; this viewpoint directly influences the design strategy used in this investigation.

Individual Differences in Navigation Strategies and Performance

It is often known that different ages have different navigational methods. Using a new virtual Y-maze strategy assessment, Rodgers et al. (2012) showed significant age differences in strategy preference, discovering that younger adults were evenly split between egocentric and allocentric (place) preferences, while older adults overwhelmingly preferred an egocentric (route) strategy. Only younger adults' performance on an independent assessment was found to be improved by a preference for allocentric strategy, showing baseline age differences in spatial strategies that could affect performance on other measures of spatial navigation. Age-related variations in hippocampus anatomy and function are used to interpret these findings (Rodgers et al., 2012).

Research has also demonstrated age-related differences in the formation and use of cognitive maps (Iaria et al., 2009) with navigational abilities determined by multiple factors including familiarity with the environment (Wolbers & Hegarty, 2010). The impact of age, sex, and hormones on place learning has been investigated through virtual navigation studies (Driscoll et al., 2005).

Numerous studies have also been conducted on the differences between the sexes in navigation. Schmitzer-Torbert (2007) investigated how humans navigated virtual multiple T mazes using place and response strategies. They discovered that early in training, place strategies were more common, whereas late in training, response techniques were more common. Men created a steadier route and learnt the correct path through the maze faster than women. Women fared better than men in both groups, and accuracy increased more quickly with place training than with response training (Schmitzer-Torbert, 2007).

Andersen et al. (2012) carried out eye tracking to assess sex differences in virtual navigation, discovering that when the number of landmarks in the environment rises, both men and women spend more time looking at them, but women rely more on landmarks to navigate. Eye monitoring demonstrated that men's landmark-oriented gaze declined over time, whereas women remained constant. Sex differences in navigating behavior existed only in environments without landmarks and disappeared in environments that contained many landmarks (Andersen et al., 2012).

Ultimately, these investigations demonstrate that individual differences in spatial cognition, age, and sex all have a substantial impact on navigation techniques and performance. The availability of landmarks and familiarity with the surroundings also influence how people navigate, while older adults typically rely more on route-based tactics. When creating interior spaces for older adults, it is crucial to take these distinctions into account since design features like color, contrast, and visual signals can act as landmarks that enhance the navigation techniques that older adults naturally favor. An important factor in the current investigation is the relationship between personal navigation preferences and ambient design.

Behavioral Measures and Age-Related Changes

Muffato et al. (2015) tested age-related differences in spatial mental representations of familiar and unfamiliar places, discovering that older adults were less accurate in visuospatial tasks and pointing at landmarks in an unfamiliar environment, but performed equivalently to young adults when pointing to familiar places. Older adults' spatial representation of familiar locations appears to be well preserved, but it deteriorates in new environments. Mental representations of both familiar and new settings are maintained by spatial abilities, although visuospatial working memory resources are solely required for the latter (Muffato et al., 2015).

In order to better understand how demographic characteristics, interact with spatial memory capacities, Campbell and Hepner (2014) investigated the effects of age and sex on memory for a familiar setting. Wilkniss et al. (1997) examined the spatial learning capacities of younger and healthy older adults. While older individuals were similarly competent at identifying landmarks along the walk, they had comparatively more trouble retracing paths and visually organizing landmarks. Older individuals had more trouble remembering and navigating routes, and the pattern of errors varied per task for each group (Wilkniss et al., 1997).

Together, these findings suggest that while older adults retain spatial memory for familiar environments, their ability to navigate and recall new spaces declines with age. This highlights the importance of designing interior environments with clear, recognizable visual cues that reduce the cognitive effort required for navigation.

Navigational Cognition and Environmental Factors

Li and Klippel (2016) examined 52 people in a university library (24 beginners and 28 specialists) and discovered that familiarity affected how they learnt location information, but environmental legibility dominated spatial awareness and navigation performance. In areas with low legibility, the route density ratio was 1.2, while in areas with excellent legibility, it was 0.40. Environmental readability was the most significant factor, indicating that effective environmental design can make up for unfamiliarity, even while pointing errors were fewer among expert users (31.27°) than novices (61.73°).

84 empirical research were compiled by Jamshidi et al. (2020) into four categories: behavior, individual differences, navigational cognition, and environmental factors. Their analysis proved that while anxiety hinders spatial memory and performance, environmental legibility, simplicity, and clear signage enhance navigation and lower stress.

These studies show that how easy an environment is to read and understand has a greater impact on navigation than individual familiarity or experience. Clear design, good signage, and visual simplicity help reduce confusion and stress for all users, making environmental legibility a key principle in designing spaces that support older adults.

Signage Design and Environmental Variables in Wayfinding

Several studies have examined the impact of signs and environmental factors on route selection. Vilar et al. (2014) evaluated how participants' route choices in everyday versus emergency scenarios during indoor wayfinding in virtual environments were influenced by environmental factors (corridor width and brightness) and signage (directional and exit signs) when presented in competition. Participants primarily selected the brighter and larger hallways in the everyday scenario with no signs, indicating a strong dependence on environmental affordances. On the other hand, participants generally followed the signals, indicating a higher dependence on signs as opposed to environmental cues. The type of intersection appears to have an impact on the dependence on environmental affordances during emergencies (Vilar et al., 2014).

Shi et al. (2020) investigated how the legibility of navigational signs in metro stations was affected by ambient illumination, color combination, sign height, and observation angle. The findings demonstrated a 14% increase in reading for passengers under greater ambient illumination. Although not by much, the achromatic color combination, white target on black backdrop, was easier to read than the chromatic color combination, yellow target on black background. Legibility was not directly impacted by the type of sign or its height. Legibility was greatly impacted by observation angle, with visibility drastically decreasing between 0° and 70°. Wayfinding signs' visibility catchment area resembled an ellipse, with a short axis that was almost equal to the sign's readability distance at 0 degrees (Shi et al., 2020).

According to the findings of these investigations, both signage and ambient factors such as brightness, contrast, and spatial layout help to assist navigation decisions. Even though signs are useful for finding their path, people also rely significantly on clues from their surroundings in the absence of signs. It is particularly crucial to make sure that signage and the surrounding environment offer clear, high-contrast visual direction for older persons, whose capacity to interpret visual information may be diminished.

Design Guidelines and Environmental Interventions for Senior Living Facilities

One crucial area where research is put into effect is the use of color, contrast, and lighting design concepts in senior care facilities and age-focused settings. In healthcare settings, lighting and color have a significant impact on patient healing, staff performance, and accessibility (Dalke et al., 2006). They advocated for the early integration of these elements into design, citing the fact that well-designed visual environments enhance mood, reduce anxiety, and facilitate wayfinding. Although their study concentrated on general healthcare settings, the ideas are especially applicable to senior living institutions where people undergo age-related changes in their vision and cognitive abilities.

Pinheiro and da Silva (2012) observed that people between the ages of 55 and 80 frequently had perceptual problems, such as increased glare sensitivity, decreased contrast sensitivity, and poor blue-green discrimination. They concluded that larger font, higher contrast, brilliant colors, and well-lit places all improve a basic universal design principle that makes it easier for everyone to read. The goal of this study, Visual Communication and Inclusive Design: Color, Legibility and Aged Vision, was to identify particular design principles that should be used to create visual communication items that are simple for everyone to read and understand (Pinheiro & da Silva, 2012).

Borges and da Silva (2015) developed a hybrid approach for hospital wayfinding that specifically considered patients at an ophthalmological hospital by combining tactile floor coding with visual elements. By determining the most effective typefaces, text sizes, and letter spacing, this user-sensing evaluation process, known as " way sensing," concentrated on legibility and readability; on the haptic evaluation of foot touch and its relationship with dexterity and balance; and on color and background contrast color definition for written material and floor stripes. Testing people with eye conditions revealed that some were unable to see 45mm letters at 5–20 cm distances, highlighting the limitations of vision-only systems (Aboim Borges & Silva, 2015).

According to van Buuren and Mohammadi (2022a), employing colors and contrasts in design can assist residents navigate and comprehend spaces more easily, which is relevant to the particular navigational issues older adults in care facilities encounter. According to their research on dementia-friendly design, spaces with distinct, contrasting borders and visual signals greatly enhance wayfinding by reducing the cognitive burden on older adults, making the space safer and easier to navigate. They created a thorough set of design standards and typologies specially to facilitate wayfinding in assisted living and care institutions (van Buuren & Mohammadi, 2022a).

Dijkstra et al. (2008) indicated that "stimulus screening ability" moderates color impacts, establishing a significant individual difference perspective pertinent to senior facility design. Those with limited screening ability (environmentally sensitive) showed less stress with green walls and more alertness with orange walls, whereas high-screeners showed no effects. This explains contradictory color research findings and suggests that disease or cognitive loss may momentarily impair screening ability, making patients and residents more color sensitive. According to this research, senior living facilities should strategically use color while considering the varying sensory processing capacities of its residents (Dijkstra et al., 2008).

Additionally, research on indoor spaces emphasizes how high contrast wall and flooring colors can enhance the navigation experience for those with visual impairments by providing crucial indications (Ghamari & Golshany, 2022). This conclusion is consistent with research by Jiang et al. (2022) who expanded on this viewpoint in hospital settings and pointed out that in order to improve psychological well-being and wayfinding efficiency, natural light and color variations must be incorporated into the design of such facilities.

Overall, these studies show that careful use of color, contrast, and illumination in senior living and hospital settings can significantly enhance navigation, lessen cognitive strain, and promote older adults' wellbeing. However, a large portion of this research concentrates on institutional settings like hospitals and care facilities, paying less attention to how older adults perceive and favor these design features in a wider variety of interior settings. This gap highlights the necessity for participant-centered research that reflects older adults' subjective comfort and preferences, which is the subject of this study.

Gap Analysis

Despite extensive studies demonstrating the significance of color and contrast for aging eyesight, its practical use is limited by key gaps. Less than 10% of the 40+ reviewed papers looked at actual facilities with resident participants; most studies rely on laboratory simulations rather than real-world senior living scenarios. Because the interaction of familiarity, cognitive load, weariness, and environmental complexity in real-world navigation cannot be replicated in laboratory settings, this compromises ecological validity. Studies standardize “older adults” based on demographics, despite the fact that the youngest-old (65-74) and oldest-old (85+) categories differ significantly. There is an absence of research on the fastest-growing population (those aged 85 and over), and multiple illnesses or different degrees of cognitive function that significantly affect navigational abilities are rarely considered. Critically, the existing literature also lacks studies that directly measure older adults’ comfort and overall satisfaction with color and contrast design choices. Most studies evaluate functional outcomes such as navigation accuracy or error rates, without capturing how design elements make older adults feel, whether spaces feel visually comfortable, whether contrast levels feel reassuring or harsh, and whether design choices align with personal preferences. This gap is significant because satisfaction and comfort are key dimensions of quality of life and independence for aging populations.

Studying separate variables, such as color, contrast, or illumination, conceptually hinders comprehension of synergistic effects. No study thoroughly examines the ways in which lighting, signage, furniture difference, wall color, and floor-wall contrast work together as a cohesive system. There aren't many prolonged studies in the field that monitor age-related changes or adaption to altered surroundings over time. Cultural preferences contradict physiological predictions: (Jaglarz, 2024) found 29% of Polish seniors preferred blue despite lens yellowing making it hardest to perceive, while Liu & Wang (2025) found 60.2% of Chinese seniors preferred orange. This 31-percentage point difference suggests culture may override physiology in design preferences. Finally, design guidelines offer universal recommendations rather than frameworks for individual variances in stimulus screening capacity (Dijkstra et al., 2008) or visual skills. Designers are unable to successfully translate findings into tailored, successful solutions for a variety of aging populations because of these shortcomings.

Discussion

Although there is a strong understanding of the physiological factors underlying age-related visual degradation in the literature, such as contrast sensitivity decreasing beyond age 60 and lens yellowing reducing the transmission of blue light, important design gaps still exist. There is a basic contradiction between physiological capabilities and psychological preferences: high-contrast red-black combos increased visibility rates, but older adults frequently favor earth tones and blue despite trouble recognizing them. Although studies show that high-legibility environments lower route density ratios from 1.2 to 0.40, they prioritize short-term wayfinding over long-term residential adaption. Equally important is the limited attention given to how color and contrast choices affect older adults' subjective comfort and overall satisfaction with interior spaces.

The reviewed literature demonstrates that aesthetic and emotional responses to color, such as Jaglarz's (2024) finding that seniors prefer familiar earth tones regardless of physiological disadvantages, suggest that comfort and preference are independent drivers of design satisfaction that cannot be inferred from functional performance alone.Studies exploring at the coordinated effects of color, contrast, lighting, and signage in real-world settings are the ones that most clearly demonstrate the research-practice gap. Despite evidence that individual differences, such as cultural origins, preferred navigation strategies, and sensory screening skills, modify the effectiveness of designs, these elements are not given enough consideration. There is a lack of implementation science research addressing real-world obstacles to evidence-based design, long-term evaluation, and ecological validation in real institutional settings.

Conclusion

The results of this review suggest that careful use of color and contrast significantly enhances spatial memory, safety, and overall comfort for older adults who are suffering from age-related visual deterioration. Beyond functional performance, the literature highlights that older adults' color preferences and subjective satisfaction with interior environments are shaped by psychological, cultural, and emotional factors that are not always predictable from physiology alone. However, putting research results into reality requires studies that look at entire environmental systems, distinguish suggestions for diverse populations, and directly measure comfort and satisfaction alongside functional outcomes. Developing design principles that support older adults' comfort, preference, and quality of life requires thorough, practical investigations to bridge the research-practice gap as populations age quickly.

CHAPTER – III: METHODS

Introduction: Research Approach and Design

This chapter describes the research methodology, design, and methods used to investigate how color and contrast strategies in interior settings influence older adults' comfort, preferences, and overall satisfaction with interior spaces. Central to this study is the use of Virtual Reality (VR) technology as a controlled, immersive simulation environment that allows participants to experience and respond to carefully designed interior conditions. In order to investigate the subjective experiences and comfort responses of older adults encountering different color and contrast conditions, this study employs a mixed-methods approach that combines structured quantitative survey data with qualitative participant feedback, expanding on the literature overview described in Chapter II. The VR environment was essential for this study as it provided a consistent, controllable setting in which participants could encounter and evaluate multiple color and contrast conditions without the variability of real-world spaces. This integrated research strategy provides a thorough understanding of how older adults perceive and respond to interior design choices by collecting quantitative comfort and preference ratings alongside qualitative open-ended feedback that reveals why specific color and contrast strategies feel more supportive, visually comfortable, or satisfying. The study is intended to determine which interior color and contrast strategies best support the comfort and visual preferences of older adults.

Research Approach and Design

This study employs a mixed-methods design that integrates:

- Quantitative Component: Structured post-navigation surveys capture participant comfort ratings, color and contrast preferences, and perceived ease of navigation across different virtual room conditions.
- Qualitative Component: Semi-structured post-navigation interviews provide subjective feedback on visibility, comfort, navigation ease, and environmental preferences.

Virtual Reality (VR) is a computer-generated, three-dimensional environment that users can explore and interact with in a seemingly real or physical way, typically through a head-mounted display (HMD). In this study, VR served as the primary platform for the quantitative component, providing a consistent and controlled setting in which participants experienced and evaluated multiple interior color and contrast conditions. Unlike real-world settings, VR allows researchers to present identical environmental conditions to every participant, eliminating confusing variables such as differences in lighting, building familiarity, or physical accessibility.

The use of VR in aging and navigation research is well-established. Maillot et al., (2012) demonstrated that VR environments are effective for assessing spatial navigation and cognitive performance in older adults while maintaining ecological validity. Cushman et al., (2008) used VR-based navigation tasks to examine age-related differences in wayfinding strategies, confirming that older adults' navigation behavior in VR closely mirrors real-world performance. More recently, Jiang et al., (2022) employed immersive virtual environments to study how interior design variables including color and spatial layout affect wayfinding efficiency in healthcare settings. These studies collectively establish VR as a validated and appropriate tool for examining how environmental design supports older adults' navigation, directly supporting its use in this study.

The virtual reality simulation enables fine control of environmental factors through photorealistic interior areas that mimic real-world settings. The following reasons made this methodological approach especially suitable for answering the study questions:

- Captures structured, quantitative ratings of comfort, color preference, and perceived visual clarity that allow meaningful comparison across participants and room conditions.
- Records subjective experiences that highlight usability issues, comfort, and confidence.
- Eliminates the dangers of conducting physical navigation investigations and enables safe, controlled testing.
- Allows for exact environmental control, which is challenging to accomplish in real-world situations.

Data Sample

The demographic group of interest is community-dwelling older adults aged between 57 and 85 years, who would be able to use virtual reality equipment and would not have significant vision impairments that prohibit screen viewing. Based on research showing that contrast sensitivity starts to decrease around age 40 and becomes more noticeable beyond age 60, this age criterion was chosen (Derefeldt et al., 1979; Sia et al., 2013).

Inclusion Criteria

The following criteria were used to determine eligibility for participation in the study:

- Age between 55 and 85 years
- Corrected or uncorrected vision sufficient for screen-based tasks

- No history of severe motion sickness or VR intolerance
- Ability to stand or sit comfortably for 15-20 minutes
- Cognitive capacity to understand and follow verbal instructions
- Willingness to provide informed consent

Exclusion Criteria

Participants were excluded from the study if any of the following conditions applied:

- Legal blindness or severe visual impairment (unable to see VR headset display even with corrective lenses)
- Diagnosis of advanced dementia or severe cognitive impairment
- History of severe vertigo, epilepsy, or seizures triggered by visual stimuli
- Recent eye surgery (within 3 months)
- Inability to wear VR headset due to physical limitations

Actual Sample

The study recruited 10 participants ranging in age from 57 to 80 years, all falling within the targeted 55–85-year age range. All participants were recruited through a lifelong learning program at a public university serving adults aged 50 and older.

Although the sample size is small, it is appropriate for a mixed-methods study of this nature. Research involving older adult participants and immersive technology requires individualized session management; each participant needs time to adapt to the VR environment, complete the navigation tasks at their own pace, and respond thoughtfully to survey and interview questions. Collecting meaningful comfort and preference data under these conditions is time-intensive, making large samples impractical within a single study phase. The controlled virtual environment further strengthens the value of a small sample by ensuring that all participants encounter identical conditions, which reduces variability and increases the clarity of responses across the group. Qualitative survey and interview data from ten participants align with established guidelines for achieving thematic saturation. Thematic saturation refers to the point in data collection at which no new themes, patterns, or insights emerge from additional interviews indicating that the dataset is sufficient and complete. According to Guest et.al. (2006), saturation can typically be achieved with as few as 6–12 participants in focused, homogenous studies where participants share similar characteristics, such as the older adult community members recruited for this study, all falling within the 55–85-year age range.

Sampling Procedure

A purposive sampling strategy was employed to recruit participants meeting the specified criteria through a lifelong learning program at a public university serving adults aged 50 and older.

Recruitment Methods:

The following recruitment channels were used to reach eligible participants:

- Course announcements: Study information shared during class sessions within the lifelong learning program.
- Email communications: A recruitment email was distributed to program members via the institute's email listserv. The email outlined the study purpose, eligibility criteria, session

details, and researcher contact information. This recruitment material was reviewed and submitted as part of the Institutional Review Board (IRB) application prior to any participant contact.

Screening and Scheduling

Interested individuals completed a brief screening questionnaire to verify eligibility based on inclusion/exclusion criteria. Selected participants were scheduled for individual testing sessions at a designated research space within the university.

Sample Balance

A total of 10 participants were recruited. Recruitment was conducted through the lifelong learning program and continued until a sufficient sample for thematic saturation was achieved.

External Validity

The external validity of this study, the extent to which findings can be generalized beyond the immediate sample is addressed here in summary and discussed in full under the Reliability, Validity, and Trustworthiness section below, where internal and external validity threats and mitigation strategies are examined together.

Strengths:

- The use of virtual interior environments that mirror real-world educational and social spaces (corridors, classrooms, reception areas) enhances ecological validity.
- Participant recruitment from a real community learning institute enhances the representativeness of the sample for older adult populations.

- Wayfinding tasks (finding restrooms, exits, reception, classrooms) represent authentic navigation challenges older adults encounter daily.

Limitations:

- The limited sample size (n=10) reduces quantitative applicability to the larger population of older individuals.
- Selective sampling may increase selection bias by expecting participants to be willing and able to use VR technology, potentially eliminating older adults with significant impairments.
- Diverse social, cultural, and educational backgrounds that affect navigation techniques and color preferences might not be represented in the sample (Jaglarz, 2024; B. Liu & Wang, 2025).
- The physical, neurological, and auditory cues present in real-world interior environments such as floor texture underfoot, ambient noise, and spatial depth perception may not be entirely replicated within virtual navigation environments, which could affect how participants respond compared to real-world conditions.

Despite these limitations, the study's findings provided important preliminary data about color and contrast methods for future research with bigger, more diverse samples and real-world validation tests.

Measurement

Variables

Independent Variables

This study employs an exploratory-comparative mixed-methods design to investigate color and contrast effects on navigation and comfort for older adults as a unified group. The study manipulated environmental design characteristics within a single virtual model:

1. Door Color: The model features doors in three contrasting colors to test visibility against wall surfaces. Each color was specified using a hexadecimal (Hex) color code; a standard digital notation used in design and 3D modeling software to precisely define colors as a six-character combination of numbers and letters (e.g., #1E3A5F), ensuring exact color reproduction across the virtual model and eliminating any variation in shade or tone between conditions. For this investigation, hex codes were used because they guarantee precise color replication across the virtual model, remove any difference in tone or shade between situations, and enable accurate estimates of luminance contrast between wall and door surfaces. In a controlled experimental context, where even slight color differences could affect participant responses and jeopardize the validity of cross-condition comparisons, this degree of color precision is crucial.

Dark blue doors (Hex: #1E3A5F), bright yellow doors (Hex: #FFD700), and green doors (Hex: #228B22). Three door color conditions were included for direct comparison, making this aspect of the study comparative rather than purely exploratory, the three door color conditions (dark blue, bright yellow, and green) were systematically compared to assess their differential effect on participant comfort, visibility ratings, and color preferences across varying levels of environmental clutter.

2. Contrast Level: Measured as the luminance difference between doors and wall surfaces.

High contrast: Dark blue doors (Hex: #1E3A5F) on light cream walls (Hex: #F5F5DC); Bright yellow doors (Hex: #FFD700) on light cream walls; Green doors (Hex: #228B22) on light cream walls. Each door color was evaluated for its luminance contrast against the standardized wall surface color used throughout the virtual model. The study examines whether door color and contrast level, in combination with environmental clutter, support better wayfinding performance.

3. Visual Clutter Density: The model included variations in furniture and decorative elements along the corridor.

- High clutter (Blue Door Room): Dense seating arrangement with bright-colored carpet, and high visual complexity along corridor surfaces
- Moderate clutter (Green Door Room): Mixed seating arrangement with dark carpet and a moderate number of furniture and decorative elements
- Low clutter (Yellow Door Room): Minimal, low-profile seating with patterned carpet and few decorative elements, representing a visually simple corridor condition

Dependent Variables

The following dependent variables were measured to assess navigation performance and participant comfort and preference during the study:

1. Task Completion Time: Duration (in seconds) from task instruction to reaching the correct door

2. Number of Hesitations: Instances where participant pauses for >2 seconds during navigation
3. Color Preference Rating: Participant-rated preference for each door color condition on a structured scale
4. Perceived Contrast Helpfulness: Participant rating of how helpful door-to-wall contrast was in locating doors (3-point scale)
5. Room Environment Preference: Participant-identified preferred room condition and open-ended reasoning
6. Navigation Errors: Number of incorrect door approaches before locating target

Subjective Measures (Qualitative/Quantitative):

In addition to objective measures, the following subjective measures were collected through post-navigation questionnaire items:

1. Perceived Navigation Ease: 5-point Likert scale rating
2. Confusion Instances: Binary (yes/no) plus descriptive location/timing
3. Door Visibility Ratings: 3-point scale (Yes/Somewhat/No)
4. Eye Comfort: 5-point Likert scale (1=Very uncomfortable to 5=Very comfortable)
5. Contrast Helpfulness: 3-point scale (Very helpful/Somewhat helpful/Not helpful)
6. Environmental Preferences: Open-ended responses about what supported or hindered navigation

Control Variables:

To isolate the effects of color and contrast, the following variables were held constant across all conditions and participants:

- Spatial layout (corridor length, width, ceiling height)
- Ambient lighting conditions
- Number and type of wayfinding tasks
- Task presentation order
- VR equipment and settings

Instrumentation

VR Headset:

The Meta Quest Pro VR headset was selected for this study due to its ability to deliver a high-quality, immersive virtual environment suitable for older adult participants. The headset provides a standalone, wireless experience with a high-resolution display and wide field of view, making it well suited for presenting detailed interior environments with varying color and contrast conditions. Its ease of setup and lightweight design reduced participant burden, which was a practical priority given the older adult sample. The Meta Quest Pro served as the environment delivery platform in this study; participants wore the headset to experience each of the three virtual room conditions and completed the post-navigation survey after each condition.

Post-Navigation Survey Instrument

A structured post-navigation survey was administered after participants completed all navigation tasks in each virtual room condition. The survey was designed to capture participant comfort, color and contrast preferences, and perceived ease of navigation across the three conditions. Questions used a mix of response formats including 5-point Likert scales, 3-point rating scales, binary yes/no responses, and open-ended questions. The instrument covered four dimensions: perceived navigation ease; color and door visibility ratings; comfort with the visual environment; and overall room preference with open-ended reasoning. The complete survey instrument is provided in Appendix A.

Virtual Environment:

A single SketchUp model was developed to replicate a section of an interior space within a public university building, representing a realistic interior environment that includes a central corridor, classrooms, and entry and exit points. The model comprises six rooms arranged as three mirrored pairs, with each pair sharing the same spatial layout and interior design. Each pair corresponds to one door color condition: two rooms with dark blue doors (Hex: #1E3A5F), two rooms with bright yellow doors (Hex: #FFD700), and two rooms with green doors (Hex: #228B22). This mirrored configuration allowed participants to encounter the same spatial conditions from different orientations while maintaining consistency across the study. The interior characteristics of each pair also varied in visual clutter: the two blue door rooms featured dense seating with a bright-colored carpet (high visual clutter), the two green door rooms featured moderate seating with a dark carpet (moderate visual clutter), and the two yellow door rooms featured minimal low-profile seating with a patterned carpet (low visual clutter). This design ensured that any observed differences in participant navigation performance could be attributed to door color and clutter rather than to differences in layout or architecture between spaces. The model included:

- Approximately 30-40 feet of corridor space
- Target destinations: Colored doors (green, yellow, blue) and participant's usual classroom
- Realistic textures and materials

The figures below illustrate the key components of the virtual study environment. Figure 1 shows the top-down floor plan of the hexagonal room configuration. Figure 2 shows the corridor view with all three colored doors visible from the hallway. Figure 3 shows the Meta Quest Pro headset used to deliver the virtual environment to participants. Photographs of the original interior space that informed the virtual model are provided in Appendix B, illustrating the spatial layout, wall surfaces, corridor proportions, and lighting conditions that were replicated in the virtual environment. Detailed photographs of each individual room condition including seating arrangement, carpet type, and clutter level are also provided in Appendix B.

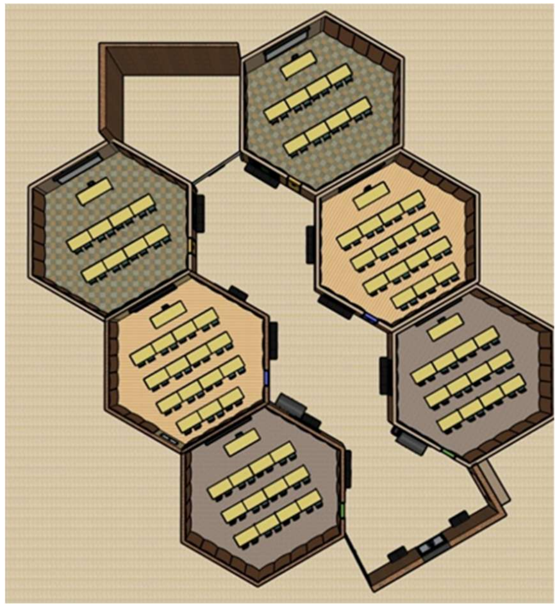

Figure 1: Top-down floor plan of the virtual study environment showing hexagonal room configuration

Figure 2: Corridor view showing blue, yellow, and green doors visible from the hallway

Figure 3: Meta Quest Pro Headset

Post-Navigation Interview Protocol:

A structured post-navigation survey and semi-structured interview guide were used to gather qualitative and quantitative data on participants' subjective experiences following each VR session. The survey and interview were designed to capture how participants felt about the visual environment, which design elements they found comfortable or uncomfortable, and which color and contrast conditions they preferred. Each category targeted a specific dimension of the experience: Navigation Experience questions explored how easily participants moved through the corridor and located target destinations; Vision and Comfort questions assessed how the visual environment affected participants' physical comfort and sense of ease; Color and Visibility questions examined how participants perceived and responded to door color and contrast levels; and Comfort Rating questions provided standardized Likert-scale ratings to allow for quantitative comparison across participants. The complete survey and interview protocol is provided in Appendix A. The four categories were:

- Navigation Experience (4 questions)
- Vision & Comfort (4 questions)
- Color & Visibility (4 questions)
- Comfort Rating (4 questions)

Questions employ a mix of formats: Binary yes/no, and open-ended responses. Participant responses were documented by the researcher in real time using structured note sheets.

Reliability, Validity, and Trustworthiness

Reliability

The following measures were used to establish the reliability of data collected in this study:

- *Test-Retest Reliability:* Structured rating scales (Likert and 3-point scales) have well-established reliability for capturing comfort and preference data, with test-retest consistency supported across similar survey-based studies in environmental design research. The use of standardized question formats and consistent administration procedures across all participants further supports the dependability of the survey data collected in this study
- *Internal Consistency:* Multiple survey administrations per participant (one per room condition, across three conditions) allow for within-subject consistency assessment of comfort and preference ratings

Validity

The following forms of validity were addressed to ensure the integrity of the study's measurements and findings:

- *Construct Validity:* Survey items measuring comfort, color preference, and perceived visual clarity are well-aligned with the study's core constructs, focusing on established approaches used in environmental preference and user experience research (Ghamari & Golshany, 2022)

- *Ecological Validity:* Virtual corridor design based on authentic educational/social spaces enhances real-world applicability

Trustworthiness

To ensure trustworthiness of the qualitative component, the following criteria were applied:

- *Credibility:* Survey responses were compared with researcher observation notes to verify consistency. Participants were asked to clarify their responses during interviews to ensure accurate understanding.
- *Transferability:* Detailed documentation of participant characteristics, environment design, and procedures enables readers to assess applicability to similar populations and contexts.
- *Dependability:* All interview notes were systematically organized. Identical protocols were used across all participants to ensure consistency.
- *Confirmability:* The research maintained a reflective journal documenting observations and decisions.

Internal Validity

Threats to internal validity and mitigation strategies:

- *Maturation:* Participants may experience fatigue or learning effects across tasks

  Mitigation: 20-second rest periods between tasks; randomized task order.

- *Testing Effects:* Repeated navigation tasks may improve performance

Mitigation: Analysis examined task order effects; tasks are sufficiently distinct (different destinations)

- *Instrumentation:* VR headset setup may vary slightly between sessions

  Mitigation: Pre-session calibration verification; post-session data quality checks

- *Selection Bias:* Participants were recruited through a lifelong learning program, which self-selects for older adults who are active, engaged, and willing to try new technology. This may not represent older adults with more significant physical or cognitive limitations.

  Mitigation: Screening criteria were applied to ensure a minimum baseline of visual and cognitive capability; demographic information was collected to identify potential confounding variables.

External Validity

- *Population Validity:* Small sample limits generalization

  Mitigation: Findings were presented as exploratory; future research with larger samples recommended

- *Ecological Validity:* Virtual environments differ from physical spaces

  Mitigation: VR model designed to closely mirror real-world interior spaces; findings acknowledged virtual-to-real translation limitations

- *Temporal Validity:* One-time measurement may not capture typical navigation behavior

Mitigation: Multiple tasks provide within-session consistency; interview questions ask about typical daily experiences

Data Collection Procedure

Data collection occurred in individual sessions lasting approximately 15-20 minutes per participant. All sessions took place in a designated room within a public university building. The room was cleared of all furniture prior to data collection to provide an open, unobstructed physical space for participants to safely wear and navigate within the VR headset, ensuring no physical hazards interfered with the virtual navigation experience.

Session Timeline

Welcome and Consent (5 minutes)

The session began with a welcome and informed consent process to ensure participants understood the study procedures and their rights.

- Greet participant and establish rapport
- Review study purpose, procedures, risks, and benefits
- Administer brief demographic and vision screening questionnaire (age, corrective lenses, visual conditions, prior VR experience)

VR Equipment Setup and Orientation Phase (5 minutes) Following consent, participants were introduced to the VR equipment and given time to become familiar with the virtual environment.

- Fit VR headset for comfort and proper positioning

- Verify Meta Quest Pro display and headset fit for comfortable, clear viewing; adjust interpupillary distance (IPD) and headset position as needed for each participant. Given that older adult participants may require additional adjustment time, up to three fit attempts were permitted before proceeding.
- Participant explores the virtual corridor freely for 1 minute to become comfortable with the VR environment
- Researcher provides brief verbal overview: "You'll be asked to find different locations in this corridor. Take your time, and let me know if you feel any discomfort."

Wayfinding Task Execution (5–10 minutes)

Participants then completed a series of standardized navigation tasks within the virtual corridor while researcher observations were recorded.

- Researcher verbally presents each task: "Please find the targeted door"
- Participant navigates until reaching the correct door
- Timer stops when participant reaches/touches the target door
- 20-second rest between tasks
- Tasks completed in randomized order to control for learning effects
- Post-navigation survey administered after completion of all tasks in each room condition

Post-Navigation Interview (10-15 minutes)

After completing the navigation tasks, participants were interviewed to capture their subjective experiences of the virtual environment.

- Remove VR headset

- Administer semi-structured interview covering:
    - Navigation experience
    - Vision and comfort
    - Color and visibility perceptions
    - Overall preferences
- Allow open-ended discussion for additional insights. The full post-navigation interview instrument, including all questions and response formats, is provided in Appendix A.

Debriefing (2-5 minutes)

The session concluded with a debriefing to inform participants about the broader study purpose and address any questions.

- Thank participant for their time
- Provide information about study purpose and anticipated outcomes
- Answer any questions

Data Recording and Storage:

The following data types were recorded and securely stored throughout the data collection process: Survey response sheets: Completed paper forms for each participant per room condition, labeled with participant ID code (no identifying information)

- Task completion times: Manually recorded by researcher in data sheet
- Field notes: Researcher observations of hesitations, verbal comments, physical reactions

All data were stored on password-protected computers and encrypted drives accessible only to the research team. Participant ID codes was used throughout to maintain confidentiality.

Ethical Considerations:

Ethical considerations were central to this study for several reasons. First, the study involved older adult participants who may be unfamiliar with VR technology, creating a responsibility to ensure their physical and psychological comfort throughout the process. Second, the collection of personal data including demographic information and behavioral observations required strict confidentiality protocols. Third, as a study involving human participants, formal ethical oversight was required prior to any data collection. The following protocols were implemented to uphold these ethical responsibilities: IRB approval was obtained before data collection began.

- Informed consent emphasized voluntary participation and right to withdraw.
- Participants were monitored for VR-induced discomfort (nausea, eye strain); session was terminated if adverse effects occurred.
- Privacy was maintained through confidential ID coding and secure data storage.

Data Analysis Procedure

This section discusses the analytical techniques applied when looking at the study's qualitative interview data as well as the quantitative survey and task performance data. In Chapter IV, results are displayed as bar graphs to facilitate an easy-to-understand interpretation of findings that lend themselves to visual comparison, such as color preference ratings and room environment preferences.

Quantitative Data Analysis

Descriptive Statistics

For all objective measures (task completion time, hesitations, comfort ratings), the following descriptive statistics were calculated:

- Measures of Central Tendency: Mean, median, mode
- Measures of Variability: Standard deviation, range, interquartile range
- Distribution Characteristics: Skewness and kurtosis to assess normality

Descriptive statistics were reported separately for:

- Each navigation task (green door, yellow door, blue door, classroom)
- Overall sample performance

Analytical Focus

Given the exploratory nature of this study and its focus on participant comfort and preference, the primary analytical approach centers on descriptive statistics, frequency analysis of survey responses, and thematic analysis of qualitative data. These methods are well suited to a sample of n = 10 and directly address the study's research questions. All results are reported for the full sample, allowing patterns in comfort, color preference, and navigation experience to be interpreted across the group as a whole.

Survey-Specific Analysis

The survey data required a dedicated layer of analysis specific to comfort and preference responses. All survey ratings were tabulated per participant and per room condition across the full sample. The following methods were applied to extract meaningful patterns from the comfort and preference data:

- *Comfort Rating Distribution:* Frequency and mean scores for each Likert and 3-point scale item, reported by room condition
- *Color Preference Ranking:* Frequency counts and ranking of preferred door colors and room environments across all participants. Also, key frequency findings including which door color participants found easiest to see and which room environment they preferred are presented as bar graphs in Chapter IV to allow for clear visual comparison
- *Open-Ended Response Analysis:* Coding of participant-stated reasons for comfort or discomfort to identify recurring themes across conditions

Qualitative Data Analysis

Thematic Analysis:

The qualitative component of this study required an analytical method capable of identifying meaningful patterns across participant interview responses. Thematic analysis was selected for this purpose because it is well-suited to interpreting subjective experiential data from small, focused participant groups (Braun & Clarke, 2006). The primary data sources for qualitative analysis were the researcher's written notes recorded during and immediately following each post-navigation interview session, along with participant verbal responses to the 16-question semi-structured interview instrument. The researcher documented participant responses in real time using structured note sheets corresponding to each interview question, ensuring all responses were captured systematically. These written records were subsequently reviewed and organized for thematic analysis. Thematic analysis was used specifically to identify recurring patterns in how participants experienced and described color, contrast, visibility, and navigational comfort within the virtual environment. The insights generated through this process were subsequently compared with the quantitative survey ratings and task performance data to identify areas of convergence and divergence between what participants described and what was recorded during navigation. Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within qualitative data. It organizes and describes the data in rich detail while interpreting various aspects of the research topic (Braun & Clarke, 2006). For this study, thematic analysis was used to understand older adults' subjective experiences navigating the virtual environment, including their perceptions of color, contrast, visibility, and comfort. This analytical approach is appropriate for this study because it:

- Allows flexibility in identifying patterns across participant interviews
- Provides rich descriptions of the dataset
- Can highlight similarities and differences across participants
- Does not require the researcher to subscribe to specific theoretical frameworks
- Is accessible and straightforward for small sample sizes

Four-Step Analysis Process:

Step 1: Data Familiarization

Interview note sheets from all 10 participants were reviewed in full and organized by question to ensure completeness and consistency. Notes were read through multiple times to develop a thorough understanding of participant responses before any interpretive analysis began. Initial observations were recorded to highlight ideas and experiences that appeared repeatedly across participants.

Step 2: Pattern Identification

Once the data were thoroughly reviewed, responses were examined across all ten participants to identify recurring patterns. Responses to each interview question were compared across participants to identify similarities, differences, and frequently mentioned experiences. Particular attention was paid to repeated references to specific colors, levels of visual clutter, navigational difficulty, and comfort as these aligned directly with the study's research questions. Patterns were noted where multiple participants independently described similar experiences, lending greater weight to those observations.

Step 3: Theme Development

Recurring patterns found in Step 2 were combined into more comprehensive themes that represented overall concepts that emerged from the data. For example, multiple participants independently commenting that darker or more saturated door colors were easier to locate led to the development of a theme such as "High Contrast as a Visual Aid." Similarly, participants describing difficulty focusing on doors in busier rooms contributed to a theme such as "Environmental Complexity as a Navigation Barrier." Each theme was clearly defined and grounded in actual participant responses rather than researcher assumptions.

Step4: Integration with Quantitative Data

In the final step, the qualitative themes identified from participant interview responses were compared with the quantitative data collected during the navigation tasks. As outlined in the Instrumentation section, the quantitative component of this study captured structured comfort ratings, color preference scores, and task performance measures including completion time and number of hesitations. In this step, those quantitative measures were examined alongside the qualitative themes to explore whether what participants described in their interviews such as finding a particular door color easier to see, or feeling more comfortable in a less cluttered room was reflected in their actual survey ratings and task performance. Where both the interview responses and the survey data pointed to the same conclusion, this was noted as convergence. Where participant verbal responses differed from their rated scores, this was noted as divergence and discussed as a point of further inquiry.

Conclusion

In order to examine how color, contrast, and environmental design influence the comfort and preferences of older adults in interior spaces, this chapter has outlined a rigorous mixed-methods approach. By combining structured comfort and preference surveys with qualitative participant feedback, the study captures both rated responses and lived experience, allowing research findings to be translated into meaningful, human-centered design recommendations.

The use of a virtual environment provides a high level of experimental control while maintaining ecological validity, the three-condition design comparing dark blue, bright yellow, and green door colors across high, moderate, and low clutter environments allows for nuanced analysis of how both color and environmental complexity interact to affect wayfinding. Although the sample size of ten participants is small, it is appropriate for this exploratory study and offers valuable preliminary data to inform future large-scale research.

Overall, the study's methodological strengths including validated instruments, standardized procedures, and a systematic framework for qualitative analysis enhance the validity and reliability of the findings. Limitations related to sample size, generalizability, and the translation of virtual results to real-world environments are acknowledged and will be addressed through recommendations for further research. Taken together, this methodological approach provides a strong foundation for translating research outcomes into practical, human-centered interior design strategies that better support aging populations.

CHAPTER IV: FINDINGS AND ANALYSIS

This chapter addresses the results of a study that investigated how color and contrast methods applied to interior settings influence older adults' comfort, preferences, and navigation experience. Ten participants, ages 57 to 80, who were all enrolled in a public university's lifelong learning program for persons 50 and older, provided the data. A post-navigation survey was conducted after each participant finished a structured virtual reality (VR) navigation session utilizing the Meta Quest Pro headset in a virtual model of an internal corridor environment. The results are arranged in accordance with the Chapter III mixed-methods design. Task performance observations with descriptive statistics, quantitative survey responses, and qualitative theme analysis are presented after participant demographics.

The data collecting instrument used for each participant session containing the full post-navigation survey, task observation log, and participant information form is described in Appendix A. For a thorough understanding of how responses were recorded and how each survey question relates to the conclusions in this chapter, readers are advised to review that Appendix A. Furthermore, Appendix B includes photos of the virtual environment as well as pictures of the original interior environment that served as the basis for the virtual model.

Participant Demographics

The study included ten participants ranging in age from 57 to 80 years (M = 72.2 years), all within the targeted 55–85-year age range. The sample was predominantly female, with seven female and three male participants. Seven out of ten participants wore glasses or contact lenses, indicating the high rate of age-related visual impairments in this demographic. Prior experience with virtual reality technology was limited: four participants had used a VR headset before, five had not, and one was unsure. Familiarity with the study building also varied; five participants were very familiar with the space, three were somewhat familiar, and one was not familiar at all. Because participants who frequently use the facility may have navigated more confidently from spatial memory, this variation in building familiarity is significant to the interpretation of Task 2 performance. Table 1 provides a summary of all demographic characteristics.

Table 2: Participant Demographic Characteristics

ID	Age	Gender	Glasses	Prior VR	Bldg. Familiarity	Notes
P1	80	M	Yes	No	Somewhat	No prior VR; hesitation noted in Task 1 to distinguish yellow color
P2	57	F	No	Yes	Very familiar	Prior VR; fastest overall in Task 3
P3	78	M	Yes	No	Very familiar	Longest Task 2 time (30 sec); 3 wrong approaches
P4	59	F	Yes	Yes	Somewhat	Prior VR; noted corner rooms as confusing
P5	77	F	Yes	Yes	Very familiar	Prior VR; no errors across all tasks
P6	78	F	Yes	No	Very familiar	No prior VR; noted blue/green confusion
P7	79	M	Yes	No	Somewhat	No prior VR; preferred

						open room for acoustics (double-hearing aid user)
P8	71	F	Yes	No	Somewhat	No prior VR; 2 wrong approaches on yellow in Task 3
P9	66	F	No	Unsure	Not familiar	Unsure of prior VR; hesitation in Task 1
P10	77	F	No	Yes	Very familiar	Prior VR; fastest Task 2 completion (3 sec)

Note: Bldg. Familiarity = self-reported familiarity with the study building. Prior VR = prior use of a VR headset before this study. All participants were recruited through a lifelong learning program at a public university.

Task Performance and Descriptive Statistics

This section reports researcher observations and descriptive statistics for all four navigation tasks. For each task, mean (M), median (Mdn), standard deviation (SD), and range are reported across the full sample (n = 10). The statistics recorded include the number of hesitations observed, the number of incorrect door approaches, and the task completion duration in seconds. In Task 1, all ten participants were instructed to find the green door, creating a uniform baseline comparison for the whole sample. In order to simplify direct color-by-color comparison under similar corridor settings, Task 3 is divided into three subtasks, one for each color of door. The complete descriptive statistics are shown in Table 2.

Table 3: Descriptive Statistics for Task Performance (Full Sample, n = 10)

Measure	M	Mdn	SD	Range
Task 1: Time to locate green door (sec)	6.6	5.0	4.7	2–15
Task 1: Hesitations observed (n)	0.2	0.0	0.4	0–1
Task 1: Wrong door approaches (n)	0.3	0.0	0.5	0–1
Task 2: Time to locate classroom (sec)	10.8	9.0	7.4	3–30
Task 2: Hesitations observed (n)	0.3	0.0	0.5	0–1
Task 2: Wrong door approaches (n)	0.6	0.0	1.0	0–3
Task 3A: Time to locate green door (sec)	5.4	3.0	6.3	2–20
Task 3A: Hesitations observed (n)	0.0	0.0	0.0	0
Task 3A: Wrong door approaches (n)	0.0	0.0	0.0	0
Task 3B: Time to locate yellow door (sec)	7.5	5.5	7.0	1–24
Task 3B: Hesitations observed (n)	0.5	0.5	0.5	0–1
Task 3B: Wrong door approaches (n)	0.6	0.6	0.6	0–1

Task 3C: Time to locate blue door (sec)	4.9	3.5	3.6	2–12
Task 3C: Hesitations observed (n)	0.0	0.0	0.0	0
Task 3C: Wrong door approaches (n)	0.0	0.0	0.0	0

Note: M = mean; Mdn = median; SD = standard deviation. Hesitation = participant pauses for 2 or more seconds, looks around, or appears uncertain before moving. Wrong door approach = participant moves toward or identifies an incorrect door before locating the correct target.

Task 1: Find the Green Door

All ten participants were directed to locate the green door as quickly and accurately as possible. Completion times ranged from 2 to 15 seconds (M = 6.6, Mdn = 5.0, SD = 4.7). The majority of participants completed the task in 5 seconds or fewer with no errors, indicating that the green door was generally visible and identifiable from the corridor. Two participants showed hesitation (P1 and P9), and three participants approached at least one wrong door (P1, P9, and P10) before locating the correct one. The greater mean relative to the median indicates that a few delayed decisions led the average upward, although everyone's experience was shorter and simpler. Overall, Task 1 created a strong baseline showing that, for this group, green was a visible and accessible color condition.

Task 2: Find the Classroom You Usually Use

In Task 2, participants were asked to find their typical classroom as fast as they could while pretending to be late for class. In contrast to test 1, which guided participants to a certain color, this test required both spatial memory and visual recognition of the appropriate door. Of all the tasks in the study, completion times revealed the most variation (M = 10.8, Mdn = 9.0, SD = 7.4, range 3–30 sec), indicating significant individual differences in determining familiarity, navigation confidence, and color recognition.

P10 finished the task in 3 seconds without making any mistakes, however P3 took 30 seconds and made three incorrect door approaches, which was the most mistakes made by a single participant during the whole research. This comparison shows how past VR experience and increasing familiarity can have a significant impact on performance, even in a small and very homogeneous sample.

Three subjects (P3, P6, and P8) showed signs of hesitation, and they all completed the test faster than expected. Participants' answers to the question of whether door color aided or hindered their navigation were equally divided: five said that color aided, and five said it hindered. Interestingly, all five of the people who reported difficulty either mentioned that it was hard to tell the yellow door from the wall or that the yellow appeared white in the lighting of the hallway. This pattern provided the dataset's first convincing indication that certain participants might have trouble seeing contrast in yellow, a result that became more obvious in Task 3.

Task 3: Locate Colored Doors in Order; Green, Yellow, Blue

The study's most straightforward and controlled color-by-color comparison was offered by Task 3. Finding the green door (3A), the yellow door (3B), and the blue door (3C) under the same corridor conditions was the order in which each participant finished the three subtasks. The consistency of the results was remarkable.

Task 3A - Green Door

Every participant was able to locate the green door with efficiency. The duration was between two and twenty seconds (M = 5.4, Mdn = 3.0, SD = 6.3). Throughout the whole sample, there were no hesitations or incorrect door approaches. One participant (P3) finished the assignment in 20 seconds, whilst the other nine finished it in 3–5 seconds, which accounts for the increased standard deviation. Because there are no mistakes, 3A is the study's clearest performance result and supports green as a color that can be consistently identified in this setting.

Task 3B - Yellow Door

The yellow door was the most difficult of the three, though this difficulty was not universal. Only a subset of participants made errors, accounting for a total of 6 wrong door approaches, while others located the door without issue. This indicates that confusion was concentrated among a few individuals rather than experienced by the entire group.

Completion times ranged from 1 to 24 seconds (M = 7.5, Mdn = 5.5, SD = 7.0), with P3's 24-second time pulling the average upward. Hesitations were observed 5 times during Task 3B, the highest among the three-color conditions, again suggesting that difficulty was present but not widespread across all participants.

Figure 4: Total Wrong Door Approaches by Door Color- Task 3 (n=10)

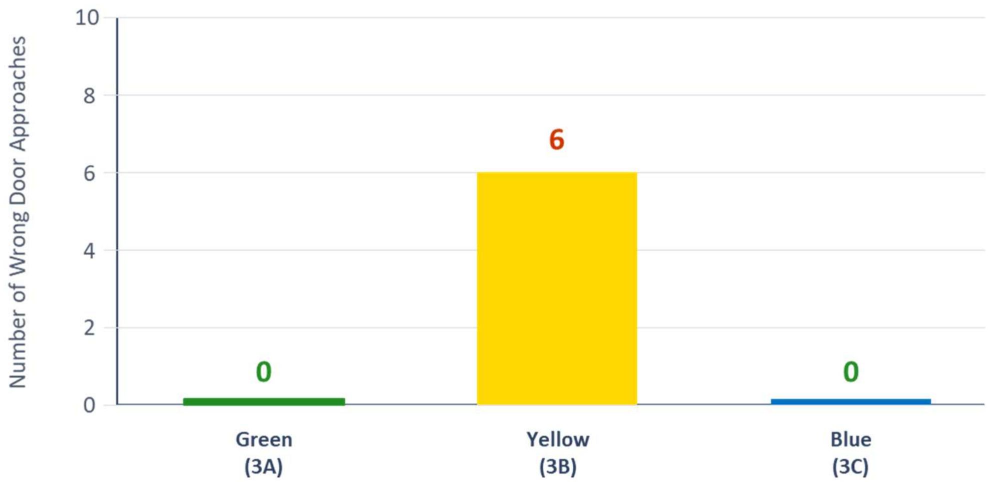

Figure 4:Total wrong door approaches by door color condition during Task 3 (n = 10). 6 wrong approaches occurred during the yellow door sub-task (3B); green (3A) and blue (3C) produced zero errors.

Several participants reported that the yellow door appeared white against the cream-colored walls, indicating low visual contrast as a likely factor. This aligns with research on age-related lens yellowing, though the effect was not consistent across all individuals. For example, P6 and P10, both older participants, made no errors, while P4 made two wrong approaches but still reported preferring yellow over the other colors.

Yellow-related confusion was also evident in Task 1, where at least two participants approached the yellow door while searching for the green one, with field notes recording "yellow as white" in both cases. This suggests that the perceptual challenges associated with yellow extended beyond Task 3B and had a broader impact on wayfinding performance throughout the study.

Task 3C - Blue Door

It was easy and fast to find the blue door. The range of completion times was 2 to 12 seconds (M = 4.9, Mdn = 3.5, SD = 3.6). For all ten participants, there were no hesitations or incorrect door approaches. Out of all the color conditions in the study, this performance was the most reliable. In the virtual corridor setting of this study, Task 3C offers the strongest performance evidence for blue as the most visually accessible door color when combined with the survey preference data shown in the following section.

Luminance Contrast Ratio and Navigation Performance

Taken together, the Task 3 results reveal a clear and consistent relationship between luminance contrast ratio and navigation performance across all three-color conditions. When each door color was evaluated against the light cream wall surface (Hex: #F5F0E8) using the WCAG 2.1 relative luminance formula, the dark blue door (Hex: #1E3A5F) produced a contrast ratio of 10.14:1 and corresponded with zero errors, zero hesitations, and a mean completion time of 4.9 seconds. The green door (Hex: #228B22) produced a contrast ratio of 3.87:1 and likewise resulted in zero errors and zero hesitations, though with a slightly longer mean time of 5.4 seconds. The bright yellow door (Hex: #FFD700), by contrast, produced a ratio of only 1.24:1 and generated all six navigation errors and five of the hesitations recorded across the entire Task 3 sequence, with a mean completion time of 7.5 seconds. These results demonstrate that luminance contrast ratio, rather than hue alone, was the primary predictor of navigation performance in this study. Every door condition at or above 3:1 produced zero errors; the single condition below that threshold accounted for every error recorded.

Figure 5: Contrast ratio ratings for blue, green, and yellow door conditions relative to the WCAG 2.1 scale, with associated navigation outcomes.

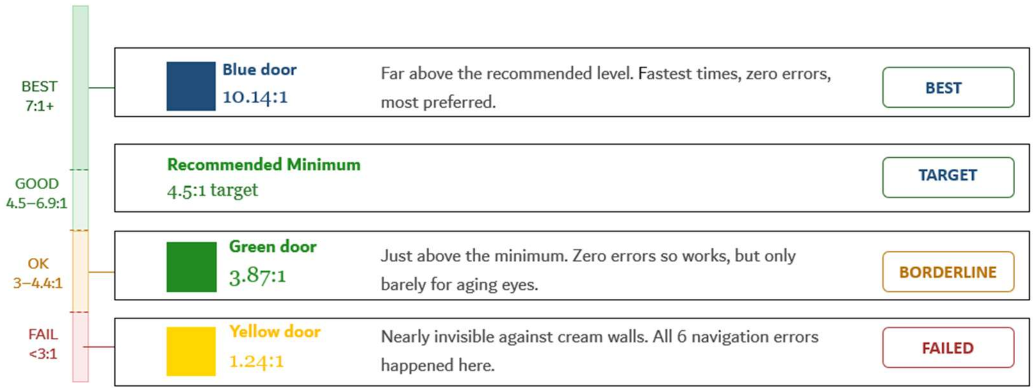

Figure 5: Contrast ratio ratings for blue, green, and yellow door conditions relative to the WCAG 2.1 scale, with associated navigation outcomes.

Task 4: View Room Images and Discuss Preference

In Task 4, participants were asked to select their preferred space and describe what made it feel comfortable or uncomfortable after viewing still photos of the three environments: open/minimal clutter, moderately cluttered, and highly cluttered. Of the ten participants, seven chose the fairly cluttered room, two chose the open room, and one chose the open room primarily due to its acoustic clarity. The extremely congested state was not preferred by any participant.

Participants who preferred a moderately cluttered space provided similar reasons. The majority reported that they could easily see and reach the entrance from where they were sitting, that the room seemed familiar, and that the furniture was organized logically. This setting seemed familiar and easy to comprehend spatially since, according to some participants, it was closest to the classrooms they frequently use. One participant summarized it well; too much clutter made the area difficult to navigate, while too much openness felt unwelcoming and confusing. The room was just the right amount of busy and balanced.

The three participants who favored the open room explained openness and ease of movement as the main reasons. One participant made an unexpected discovery: they were able to hear more clearly when there was less visual clutter. This finding connects visual and auditory comfort in a way that matches the multidisciplinary way that older individuals perceive interior spaces.

Post-Navigation Survey Results

Following the navigation tasks, all ten participants completed the structured post-navigation survey. This section reports frequency counts and percentages for each survey question across the full sample. Table 3 presents individual participant responses for each question, and the narrative sections below discuss the patterns observed.

Table 4: Post-Navigation Survey Responses by Participant

ID	Q1 Ease	Q3 Saw doors	Q4 Hesitated	Q5 Colors vs walls	Q6 Contrast	Q7 Easiest color	Q9 Environment	Q12 Eye comfort	Q13 Like real setting
P1	Okay	Yes	Yes	Yes	Somewhat	Blue	Moderate	5	Yes
P2	Very easy	Somewhat	No	No	Somewhat	Green	Open	5	Yes
P3	Okay	Yes	Not sure	Yes	Somewhat	Blue	Moderate	5	No
P4	Easy	Yes	No	Yes	Very helpful	Yellow	Open	5	Yes

P5	Very easy	Yes	Not sure	Yes	Somewhat	Blue	Moderate	5	Yes
P6	Easy	Yes	No	Yes	Very helpful	Blue	Moderate	5	Somewhat
P7	Very easy	Yes	No	Yes	Somewhat	Blue	Open	5	Yes
P8	Very easy	Yes	No	Yes	Very helpful	Blue	Open	5	Yes
P9	Okay	Yes	Yes	Yes	Somewhat	Green	Moderate	5	Somewhat
P10	Very easy	Yes	No	Yes	Very helpful	Green	Moderate	5	Somewhat

Note: Q2 (confusion query), Q8 (color blending), and Q10–11 (room preference and comfort reasoning) are reported narratively as they were open-ended responses.

V. helpful = Very helpful.

A. Navigation Experience (Q1–Q4)

Question 1 asked participants how easy it was to find the doors in general. Three of the participants said "okay," two said "easy," and five said "very easy." The virtual environment's color and contrast conditions were generally enough to facilitate successful navigation, since no participant reported finding it challenging or extremely tough. Given that six of the ten participants had little to no prior VR experience, this favorable outcome is significant. It suggests that the environment's visual design, rather than interface familiarity, was the main factor influencing navigation ease.

Question 2 asked participants if they felt confused at any point while navigating, and if so, where and when. Seven out of ten participants associated their hesitancy or confusion to the VR controller rather than the visual surroundings. This is a crucial distinction to make when analyzing the data from the observation log: hesitations noted during activities could be a stronger sign of interface unfamiliarity instead of trouble reading door colors or hallway features. Recommendations for future VR-based research with older adult populations are also included in Chapter V, where this finding is acknowledged as a contextual limitation of the study.

While navigating through the corridor, nine out of ten participants said they could see the doors clearly from a distance (Q3), with one saying "somewhat." This strong result suggests that the door colors were generally prominent and visible at corridor distances, confirming the study's color contrast settings as satisfactory. Six individuals responded negatively, two agreed, and two were undecided when asked if they observed themselves stopping while looking for the right door (Q4). This pattern is consistent with what was noted during the navigation tasks, when hesitations were most common during Task 2 and the yellow door sub-task in Task 3. This suggests that hesitation was condition-specific rather than a general navigation challenge.

B. Vision and Comfort (Q5–Q6)

Nine out of ten participants claimed door colors were easily visible against the walls (Q5), whereas one responded no. This serves as a reminder that some people may still find a design condition difficult, even if the majority of people find it accessible. When selecting design choices for this audience, group-level outcomes should not be the sole factor considered because visual experiences can differ significantly among older individuals, even those of similar age.

Question 6 discussed how useful the contrast between walls, doors, and other elements was for locating the doors. It was described as "very helpful" by four people and "somewhat helpful" by six. Every participant found color contrast to be at least somewhat helpful for recognizing doors; none reported that the contrast was not helpful. Interestingly, individuals who considered contrast as 'very helpful' performed the navigation tasks with fewer errors, implying that seeing contrast more strongly might contribute to more confident and accurate navigation.

C. Color and Visibility (Q7–Q11)

In Question 7, participants were asked which door color was most visible overall. Six out of ten participants (60%) chose blue, making it the most preferred color. Three individuals (30%) chose green, and one (10%) chose yellow. This outcome is in line with the task performance statistics from Task 3, where all ten participants had zero incorrect door approaches and blue delivered the lowest mean completion time. Blue was the most favored and best-performed color condition in this study, according to both the survey response and the task data. These findings are displayed as a bar graph in Figure 5.

Figure 6: Participant- Identified Easiest Door Color to See (Q7, n=10)

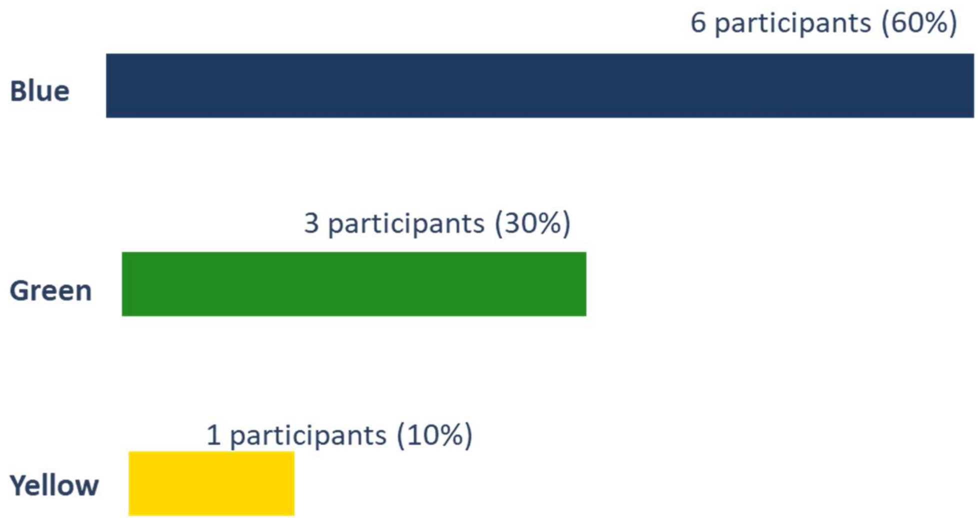

Figure 6: Participant-identified easiest door color to see (Q7, n = 10). Blue was selected by 6 of 10 participants (60%), green by 3 (30%), and yellow by 1 (10%).

Question 8 asked whether any door color blended into the surroundings or caused confusion. Three participants specifically named yellow (P1, P2, P8), and one participant (P6) identified blue and green as confusing when positioned in opposing directions within the corridor. Four participants reported no blending issues, and one left the response blank. The concentration of yellow responses across this question and the observation log together provide strong evidence that yellow was the most confusing color condition in this study.

Question 9 asked which environment felt easiest to navigate. Six participants selected moderately cluttered and four selected open or minimally cluttered. No participant selected the highly cluttered condition, which is consistent with the Task 4 image preference data. Figure 6 presents the room environment preference data as a bar graph. Questions 10 and 11 gathered open-ended responses about room preference and comfort. Responses were consistent with Task

4 findings: the moderately cluttered room was most frequently preferred for its sense of familiarity and balanced spatial arrangement, while the open room was preferred by those who prioritized ease of movement and unobstructed sightlines. Furniture layout, specifically the relationship between seating position and door visibility was the most commonly cited comfort factor across both questions.

Figure 7: Preferred Room Environment Task 4 (n=10)

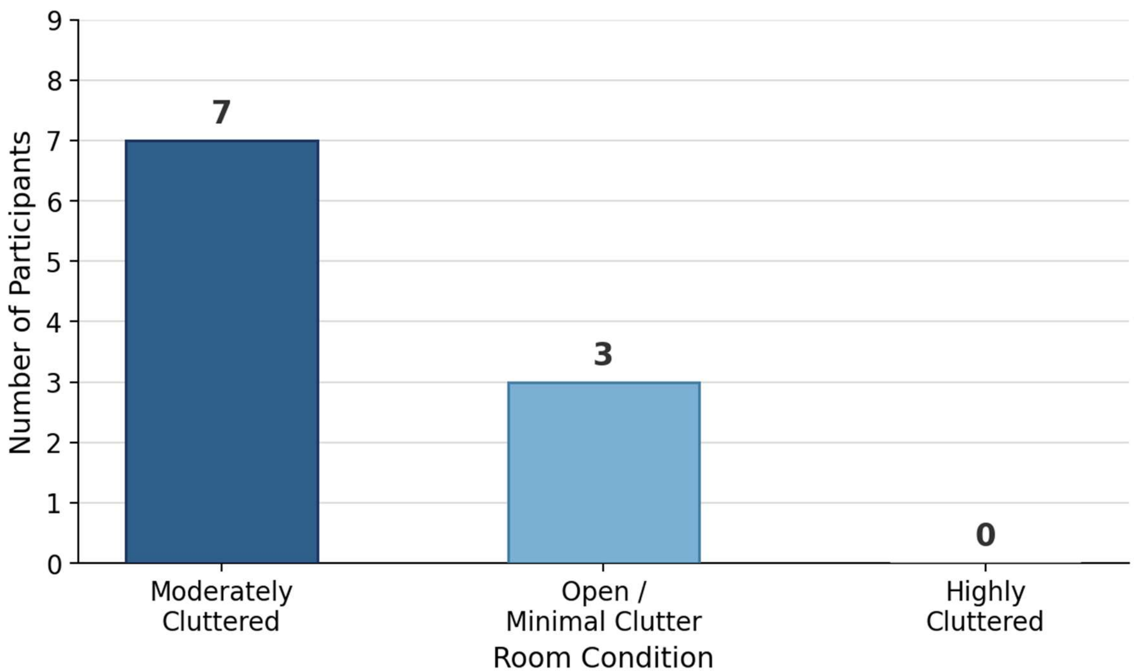

Figure 7: Preferred room environment as identified by participants during Task 4 and confirmed in Q9 (n = 10). Seven of 10 participants preferred the moderately cluttered condition; no participant preferred highly cluttered.

D. Comfort Rating (Q12–Q13)

All ten participants rated their eye comfort during the VR experience as 5 out of 5, 'very comfortable.' This unanimous result is one of the most significant findings of the study. It indicates that no participant experienced visual discomfort, eye strain, or fatigue during the session, regardless of their age, visual correction status, or prior VR experience. This finding supports the Meta Quest Pro headset's suitability for older adult participants and suggests that the VR environment did not impose a visual burden, implying that any difficulty participants encountered during navigation was due to design conditions, specifically color and clutter, rather than discomfort with the technology.

In Question 13, participants were asked if the virtual environment felt like the actual classroom setting they typically utilize. Six said "yes," three said "somewhat," and one said "no." The SketchUp model's accuracy is supported by the fact that most participants thought the virtual environment was similar to the actual place. This is a positive result because it implies that participants were reacting to a real, familiar environment rather than an abstract one, which made their comfort and preference responses more significant and based on actual experience.

Thematic Analysis

Qualitative data from open-ended survey responses, Task 4 room preference discussions, researcher observation notes, and participant comments during sessions were analyzed using the four-step thematic analysis process described in Chapter III. Following data familiarization, pattern identification, theme development, and integration with quantitative data, four primary themes emerged. Each theme is presented below with supporting evidence drawn from participant responses and cross-referenced with the quantitative task and survey findings.

Theme 1: Blue as the Most Visually Accessible and Preferred Door Color

The most consistent finding across all data sources in this study was visual accessibility and a preference for blue as a door color. Task 3C, the blue door sub-task, showed zero incorrect door approaches, zero hesitations, and the lowest mean completion time of any color condition in Task 3 (M = 4.9 sec, Mdn = 3.5 sec). In Q7, six out of ten participants (60%) said that blue was the easiest color to see overall. In final remarks and preference conversations, a number of participants specifically mentioned blue as their favorite color; no participant mentioned that blue confused them or blended in with their surroundings.

This dataset's distinctive and most constant pattern is the intersection of performance data and self-reported blue preference. This finding is consistent with previous research on color contrast and aging vision; dark, saturated colors against pale surfaces provide greater luminance contrast, which is especially relevant for older persons whose contrast sensitivity has decreased. A number of individuals reported that green and yellow felt "brighter" or more visually demanding in compared to blue, which may possibly be attributed to its cooler, lower-wavelength nature. From a design standpoint, this research supports the usage of dark blue or navy tones as door identifiers in interior spaces frequented by older adults, especially when the surrounding wall surfaces are light or neutral in color.

Theme 2: Yellow Caused Consistent Visual Confusion Due to Low Perceived Contrast

Yellow was the most consistently challenging color across all tasks and survey responses. Task 3B caused all ten incorrect door approaches recorded during Task 3, resulting in every error in that sequence, whereas green (3A) and blue (3C) produced no errors. During 3B, five individuals hesitated, the most of any color condition. In Q8, three participants particularly identified yellow as the color that blended into the surroundings or caused confusion. Several participants indicated that the yellow door seemed white against the corridor walls, making it difficult to recognize as an individual component.

The physiological research on aging color vision examined in Chapter II directly supports this conclusion. It becomes harder to differentiate yellow tones from comparably pale or warm-toned backgrounds as people age due to the crystalline lens's continual yellowing. The research's setting, which included a bright yellow door (Hex: #FFD700) set against light cream walls (Hex: #F5F5DC, produced the exact type of low-contrast situation where this age-related alteration had the biggest effect. It's also interesting that this challenge persisted despite the fact that the majority of participants thought the environment's overall color contrast was beneficial (Q6). This implies that rather than yellow, their favorable evaluations were probably influenced by how distinctively green and blue stood out.

These findings have significance for interior design. Although yellow is often suggested as a high-visibility color in accessibility literature, this study indicates that the surrounding wall color has a significant impact on its efficacy. Bright yellow may not offer enough contrast for older persons to accurately identify doors in areas with light-toned walls. Before choosing yellow as the main color indicator for older adult spaces, designers should carefully consider the particular wall tones and lighting of a space.

Theme 3: Moderate Environmental Clutter Supports Comfort and Spatial Legibility

In Task 4, seven out of ten participants stated that the moderately congested room was their preferred setting, and in Q9, six out of ten indicated that it was the easiest to navigate. The extremely cluttered room was not preferred by any participant. When it came to the open room, four people indicated it was the simplest to navigate, but only three said it was their preferred setting. This indicates that although one participant found the open room easier to navigate, they still liked the moderate space overall. This serves as a reminder that personal comfort and ease of navigation are two different factors, and older adults may evaluate them differently when deciding which environment is best for them.

One participant who preferred the open space gave an unexpected but intriguing explanation: they believed that less visual distraction allowed them to hear more clearly. Even though this was just one person's experience, it shows that comfort in a location requires more than simply vision. Visual design study may not adequately capture how a space's appearance and sound can impact older folks.

Theme 4: VR Interface Unfamiliarity as a Contextual Factor in Navigation Behavior

According to seven out of ten participants, using a VR controller was the primary cause of their confusion or hesitation when navigating (Q2). This was true regardless of participants' prior VR experience, indicating that most people needed some time to get used to the particular interface utilized in this study. This is supported by the fact that hesitations were distributed equally throughout the sample rather than being concentrated among individuals who had never used virtual reality before. It had less to do with personal skill and more to do with a shared struggle.

This is important when interpreting task performance statistics. Some of the hesitations and longer completion times seen throughout the sessions could have been due to confusion about how to navigate inside the VR environment, rather than trouble seeing or identifying the correct door. In Q2, a number of participants who paused throughout tasks revealed that they were confused by the controller rather than the colors, which was consistent with what was seen during the session.

The study's conclusions about color and contrast are unaffected by this. Yellow performed lower than green and blue across all 10 participants, which was too constant to be explained only by interface confusion. It does, however, recommend that prior to recording any task data, future VR research including older persons should incorporate a specific orientation time, ideally lasting five to ten minutes. This would make the visual design findings cleaner and more trustworthy by allowing participants to get used to the controls before their navigational behavior is monitored.

Summary of Findings

The results of this study provide a clear and consistent picture of how color, contrast, and room environment affect older persons' visual comfort and ability to navigate interior environments.

Blue stood out as the strongest most effective across every measure in this study. Six out of ten participants said it was the simplest color to see, it had the lowest mean completion time of any color condition, and it prompted zero incorrect door approaches and zero hesitations in Task 3. Blue was not confusing or hard to identify for any participant. Compared to the other two colors, a number of people said it was more aesthetically pleasing. Blue is the study's most well-supported conclusion due to the consistency of this outcome across participant behavior during navigation and survey responses.

Yellow told the opposite story. It generated all ten incorrect door approaches that were noted during Task 3, while neither green nor blue delivered any. During the yellow door subtask, five participants hesitated, the most of any one condition. According to several participants, yellow was difficult to detect as a distinct element and seemed white against the corridor walls.

In Q8, three respondents indicated that yellow was the color that confused them the most. The commonly accepted belief in accessibility design that bright yellow is always a high-visibility color is called into question by this. According to this study, yellow's usefulness is highly dependent on the color of the wall. It may not offer enough contrast for older adults to walk safely in settings with pale walls.

Green performed well throughout the study. Three participants found it to be the color that was easiest to perceive, and it generated zero errors in Task 3. It was a reliable substitute color condition in this setting because, despite not matching the preference levels of blue, it consistently offered accurate navigation and generated no reported confusion.

The results on the room environment were equally evident. The moderately cluttered environment was chosen by seven out of ten participants, while the severely congested condition was not preferred by all. Because they could see the entrance clearly from a seated position, participants described the moderate room as familiar, well-designed, and easy to keep orientated in. This research demonstrates that comfort in a setting involves more than just aesthetics for older adults. Maintaining visual access to the exit and spatial awareness without moving around is also important.

Throughout the entire session, all 10 participants rated their eye comfort a score of five out of five. This unanimous outcome demonstrates that the Meta Quest Pro headset and the VR environment was well received by the older adult group and did not result in any discomfort or visual fatigue. The majority of participants also stated that the virtual environment felt similar to the real place they use on a regular basis, supporting the environmental realism of the study's VR model.

One significant conclusion was that seven out of ten participants reported that their hesitancy during navigation was caused by the VR controller rather than trouble seeing the doors. While this had no impact on the color and contrast findings, which were consistent enough across all 10 participants to rule out interface confusion as a cause, it does raise a methodological question for future research. Before task data collection starts, studies utilizing virtual reality with older adult populations should incorporate a planned orientation period. This will allow participants enough time to get used to the interface before their navigation behavior is recorded.

Considered together, these findings give a clear, participant-centered picture of how color and contrast choices in interior environments affect older adults' experiences, and serve as a solid foundation for the design recommendations described in Chapter V.

CHAPTER V: DISCUSSION AND RECOMMENDATIONS

Introduction

This chapter interprets the findings presented in Chapter IV in relation to the existing literature reviewed in Chapter II and the research questions established in Chapter I. The discussion is organized around four data-driven themes: the visual accessibility of blue as a door color, the visual challenges associated with yellow in low-contrast environments, the role of moderate environmental clutter in supporting comfort and spatial legibility, and the impact of VR interface familiarity on navigation behavior. Each subject is thoroughly explained, with references to previous research on aging vision, color contrast, and interior environments for older adults. In order to let researchers, apply these findings to actual interior environments, evidence-based design recommendations are offered after the discussion. A summary of the research's limitations and potential future research areas is included at the end of the chapter.

The study was guided by three research questions: how color and contrast strategies affect older adults' comfort and preference; which specific applications of color and contrast are preferred; and how spatial layout and visual cues interact with color and contrast to improve overall satisfaction. The results of this study offer significant, participant-centered answers to each of these questions and add new research findings to a collection of literature that, up until recently, has mostly concentrated on functional navigation outcomes rather than subjective comfort and choice.

Discussion

Blue as the Most Visually Accessible Door Color

While the findings identify clear differences in color visibility and preference, their significance lies in the interaction between physiological limitations and subjective perception. The study's conclusion that blue was the most consistently favored and effective door color is both significant and consistent. Task 3C, the blue door sub-task, resulted in zero incorrect door approaches and zero hesitations throughout the sample, and six out of ten participants said that blue was the easiest color to perceive overall (Q7). These findings are very consistent across behavioral and self-report data sources, contributing significant support to the conclusion that blue color provides effective visual contrast for older adult users in a similar type of corridor environment.

This finding seems to be consistent and builds upon Wang and Cho's (2022) study, which found that high-contrast color combinations, especially red-black, significantly improved door sight for older persons, including those with cognitive impairment. Although their study used a different color combination, the core principle is the same: darker, more saturated colors against pale backgrounds create stronger luminance contrast, which helps compensate for the reduced contrast sensitivity that naturally comes with age. Sia et al. (2013) documented this decline in a study of 231 older adults, finding that contrast sensitivity dropped significantly with age even in people with otherwise normal vision. Sia et al. discovered that, even in those with otherwise normal eyesight, the contrast sensitivity of the oldest group (aged 71–85) was two to four times worse than that of the 60–70-year-old group, especially at high spatial frequencies. Similar findings were made by Derefeldt et al. (1979), who discovered that contrast sensitivity decreases dramatically around the age of 60, especially in the mid-to-high spatial frequency areas involved in recognizing edges and fine detail perception. Together, these investigations show that high brightness contrast at the door-wall interface is a physiological requirement for older adult environments rather than just a design choice.

This conclusion is especially intriguing because it seems to contradict some of the physiological literature. According to Liu and Wang (2025), short-wavelength (blue) light transmission is decreased in older individuals with age-related lens yellowing, which may make blue more difficult to see. However, on every metric in this study, blue did better than both green and yellow. The difference between identifying a particular hue and identifying a luminance contrast could help to explain this. While lens yellowing reduces blue wavelength transmission, the blue color employed in this study produced such a significant luminance contrast against the cream wall surface that it was easily visible even for participants with age-related visual impairments. This research has significant consequences for how designers choose and specify colors in older adult situations, as it implies that a color's lightness value and saturation may be more important for door recognition than its hue alone.

It is also noteworthy that a number of individuals described blue as less visually demanding and said it felt more visually comfortable than either green or yellow. This relates to research by Dijkstra et al. (2008), who discovered that people with decreased stimulus screening ability, a condition linked to aging and cognitive decline react more strongly to color cues in their surroundings. A color that offers distinct contrast without causing visual disturbance can be very helpful for older adults. Blue's cooler, less stimulating nature may add to a sensation of visual ease while yet providing the contrast required for accurate identification.

Yellow and the Problem of Insufficient Luminance Contrast

The most evident and most practical outcome of this investigation is represented by the yellow door findings. While green (3A) and blue (3C) caused no errors, all ten incorrect door approaches that were recorded during Task 3 happened during the yellow sub-task (3B). Three participants particularly identified yellow in Q8 as the color that generated the most confusion, while five individuals hesitated during 3B, the highest hesitation count of any single condition. According to several participants, the yellow door was unrecognizable from the surrounding surface because it seemed white against the corridor walls. This result directly illustrates the physiological alterations reported in the literature in real world. According to Ishihara et al. (2001), yellow-white is one of the four color combinations that older adults find most challenging to discern. This is because an older adult's ability to distinguish between warm-toned colors and pale backgrounds is diminished by the crystalline lens's progressive yellowing. This identical scenario was produced by the study's circumstances, which included a bright yellow door (Hex: #FFD700) against light cream walls (Hex: #F5F5DC). Even though the brightness difference between these two colors was noticeable to younger eyes, several participants were unable to consistently distinguish the yellow door from the wall. This result clearly challenges a common belief in environmental design and accessibility. Design guidelines and wayfinding literature often mention yellow as a high-visibility color, especially for people with impaired eyesight and older adults. High contrast and vivid colors were suggested by Pinheiro and da Silva (2012a) as a component of inclusive design. In older adult situations, navigation is aided by contrasting colors and visual cues, according to Van Buuren and Mohammadi (2022b). However, neither of these recommendations considers the specific interaction between the chosen color and the surrounding surface, which is a significant variable highlighted by this study.

Hence, it is not implied that yellow should be completely avoided, but rather that its application needs to be considered in the context. Bright yellow would probably produce a significant brightness contrast and behave considerably differently against a dark wall surface, such charcoal grey or deep brown. The perceptual blending seen in this study is produced by the mix of yellow with pastel, warm-toned wall surfaces. Before deciding to use yellow as a door color identifier in spaces which cater older adults, designers should carefully consider the lighting and wall color of the area. They should also think about using a luminance contrast calculator to confirm that the combination satisfies recommended thresholds for age-related visual access. It's also remarkable that this visual challenge continued despite the fact that the majority of participants thought the environment's overall color contrast was beneficial (Q6). Contrast was assessed as "somewhat helpful" by six people, "very helpful" by four, and "not helpful" by none. This implies that participants' favorable evaluations of contrast were influenced by their interactions with the green and blue conditions rather than the yellow ones, serving as a reminder that overall satisfaction scores might obscure condition-specific challenges that can only be identified by behavioral observation and specific survey questions.

Understanding WCAG 2.1 Contrast Ratio Thresholds

WCAG, or the Web Content Accessibility Guidelines, is an internationally recognized set of accessibility standards developed by the World Wide Web Consortium (W3C). Although originally created to evaluate contrast between text and background colors on digital screens, the WCAG contrast ratio formula is grounded in the physics of human visual perception, specifically, the measurable difference in relative luminance between any two surfaces. Due to this, the formula has been widely implied beyond digital design and is now used in environmental, architectural, and wayfinding research as a reliable, standardized method for quantifying how visually distinct one surface is from another. In this study, the WCAG 2.1 relative luminance formula was applied to calculate the contrast ratio between each door color and the surrounding wall surface. WCAG defines three conformance levels based on this ratio. The AA level (minimum 4.5:1) is the standard accessibility threshold and represents the level at which most users, including those with moderate visual impairment, can reliably distinguish between two surfaces. AA large (minimum 3:1) is a relaxed version of the AA threshold that applies specifically to large-scale elements such as architectural features, doors, or signage where size compensates for some loss of contrast. The AAA level (minimum 7:1) is the enhanced threshold representing the highest level of visual accessibility, providing sufficient contrast even for users with significant visual decline. A result below 3:1 constitutes a failure under any conformance level, indicating that the contrast between two surfaces is likely insufficient for reliable visual discrimination, particularly for older adults whose contrast sensitivity has declined.

The WCAG 2.1 contrast ratio scale provides a useful framework for evaluating these thresholds in practice. Ratios below 3:1 represent a failure condition in which color effectively blends into the background for aging eyes, making reliable identification unlikely. Ratios between 3:1 and 4.4:1 are minimally acceptable for large elements such as doors, though they may still present difficulty for users with more advanced visual changes. Ratios between 4.5:1 and 6.9:1 meet the standard AA threshold and represent a reliably accessible range. Ratios at or above 7:1 satisfy the AAA threshold and represent the highest level of visual accessibility. The three door colors used in this study map directly onto this scale: dark blue (10.14:1) sat firmly in the AAA range; green (3.87:1) met the minimum for large elements but fell short of the recommended 4.5:1 target; and yellow (1.24:1) failed entirely, falling nearly one third of the way to even the lowest acceptable threshold. A minimum target of 4.5:1 is recommended for all door-to-wall color pairings in spaces serving older adult populations, with a preference for ratios above 7:1 wherever possible. It's also remarkable that this visual challenge continued despite the fact that the majority of participants thought the environment's overall color contrast was beneficial (Q6). Contrast was assessed as "somewhat helpful" by six people, "very helpful" by four, and "not helpful" by none. This implies that participants' favorable evaluations of contrast were influenced by their interactions with the green and blue conditions rather than the yellow ones, serving as a reminder that overall satisfaction scores might obscure condition-specific challenges that can only be identified by behavioral observation and specific survey questions.

Moderate Environmental Clutter and the Intersection of Comfort and Legibility

In Task 4, seven out of ten participants favored the moderately congested room, while in Q9, six out of ten chose it as the most approachable setting. The highly cluttered room was not preferred by any participant. These findings align with a wider range of research on environmental legibility and how it helps older adults navigate and feel comfortable.

Li and Klippel (2016) found that environmental legibility; how easily a space can be read and understood was the most important factor affecting navigation performance in their study of 52 participants, even more so than how familiar participants were with the space. Their research showed that clearer, more legible environments made navigation significantly more efficient. The moderately cluttered condition in this study appeared to reflect the right level of complexity; purposeful and familiar enough to feel comfortable, but not so busy that sightlines were blocked or the space became visually confusing.

Research on environmental familiarity and comfort also supports the preference for moderately cluttered over open space. According to Luo et al.(2024), older adults' comfort and cognition are greatly influenced by their indoor visual environment; familiar and contextually appropriate places encourage more ease and participation. The study's participants reported that the moderately cluttered space seemed like the actual classrooms they frequently use. Therefore, this sense of familiarity probably influenced the ease with which they evaluated the space. This implies that designers should strive for a degree of spatial complexity that mimics the settings that older adults are familiar to and can confidently navigate rather than simply reducing visual components in an attempt to lessen confusion. The distinction that participants made between comfort and navigability was one of the theme's most profound findings. Only three participants chose the open room as their preferred setting in Task 4, despite the fact that four individuals said it was the simplest to navigate in Q9. This difference shows that the ideal interior space for older individuals is not necessarily the easiest to navigate; rather, it is one that balances ease of navigation with a sense of spatial occupancy and belonging. This relates to the research of Jaglarz (2024), who discovered that psychological and emotional aspects that extend beyond functional ability influence the environmental choices of older persons. Even though it is technically simpler to navigate, an area that is too small may feel unwelcoming or confusing.

The discovery that one participant preferred the open space for acoustic reasons stating that open setting allowed them to hear more clearly, adds an essential dimension that this study did not intend to capture. It reflects the multidisciplinary character of older adults' environmental experiences and is consistent with the broader knowledge in gerontological design research that the visual, auditory, and spatial components of interior settings interact in ways that cannot be addressed alone through visual design. The literature's appeal for more comprehensive, multidisciplinary approaches to inclusive interior design is supported by this observation.

VR Interface Familiarity as a Methodological Consideration

Seven out of ten participants associated their hesitancy or confusion to using the VR controller rather than having problems identifying the doors (Q2). Regardless of prior VR experience, this pattern was constant, indicating that most participants including those who had previously used VR headsets in different contexts, needed some time to get used to the particular interface utilized in this study, the Meta Quest Pro. This finding does not undermine the study's conclusions about color and contrast. For all 10 participants, the pattern of yellow doing worse than green and blue was too strong and constant to be accounted for by interface confusion. It would be highly unlikely if controller confusion were the main cause, because participants who paused because of controller doubt nonetheless finished Task 3C (blue) without errors just after finishing Task 3B (yellow) with errors. However, this discovery raises an important methodological question for future VR research with older adults. Cushman et al. (2008) validated VR as an ecologically valid research platform by showing that older adults' navigation behavior in VR closely resembles real-world performance. Similarly, Maillot et al. (2012) verified that VR environments are useful for evaluating older persons' cognitive and navigational abilities. These studies do not adequately address the issue of interface orientation time, which is the time before task data collection begins when participants get comfortable with the system's specific controls and navigation mechanics.

In this study, participants were given two minutes of free exploration before beginning activities. This was insufficient for many participants to have complete confidence with the controller, according to the Q2 comments. Further research should include a structured orientation phase of at least 5 to 10 minutes, as well as guided practice tasks that reflect the navigation requirements of the real study tests. This would produce clearer and more trustworthy data on how environmental design factors affect older adult navigation by reducing the extent to which technological familiarity influences visual design findings. It's also important to note that during the entire session, all ten participants gave their eye comfort a rating of five out of five, and most of them acknowledged that the virtual environment seemed like the real place they frequently use. These findings support both the practical reality of the SketchUp model and the Meta Quest Pro headset's suitability for older adult participants. They point out that the main issue was interface mechanics rather than immersion or visual experience, and that the VR platform itself was well suited to this demographic in terms of visual quality, display comfort, and environmental fidelity.

Addressing the Research Questions

Research Question 1: How Do Color and Contrast Strategies Influence Comfort and Preference?

The results of this study strongly show that color and contrast strategies have a direct and quantifiable impact on older adults' comfort and ability to navigate interior spaces. This is most clearly demonstrated through the WCAG contrast ratios recorded for each door color condition, which aligned closely with both navigation performance and participant comfort ratings. The blue door achieved a contrast ratio of 10.14:1 against the cream wall surface, far exceeding the recommended minimum of 4.5:1, and correspondingly produced the best navigation performance and highest preference ratings across the study. The green door recorded a borderline ratio of

3.87:1, just below the recommended threshold, and while it produced no navigation errors, participants rated it as less visually comfortable than blue. The yellow door recorded the lowest ratio of 1.24:1, failing the contrast standard entirely, and produced the greatest number of errors and reported confusion across all conditions. These findings demonstrate that color selection in older adult spaces is not only an aesthetic choice but also a practical one with significant implications for how correctly and comfortably people move around. However, the study also found that objective performance and subjective comfort do not always align perfectly. Despite yellow causing all recorded navigation errors, some participants still rated the overall contrast in that environment as helpful, highlighting the importance of using both behavioral observation and self-report measures together when evaluating color and contrast strategies.

Research Question 2: Which Specific Applications of Color and Contrast Are Most Preferred?

Participants consistently chose dark, high contrast colors, particularly blue when applied to light wall surfaces. Both task performance and survey responses showed that people preferred blue over green and green over yellow. The door-to-wall relationship was found to be the most important design factor in terms of contrast application; doors that were immediately recognized and strongly liked were those that were different from the wall surface in terms of both hue and lightness value. The wall-door contrast condition that produced the clearest performance was blue on light cream, a high-luminance contrast pairing that is consistent with the contrast sensitivity research of Sia et al. (2013) and the color visibility findings of Wang and Cho (2022). The condition that produced the lowest performance was bright yellow on light cream, a low-luminance contrast pairing that illustrates exactly the type of color combination Ishihara et al. (2001) identified as most problematic for older adults.

Research Question 3: How Do Spatial Layout and Visual Cues Interact with Color and Contrast?

The results of Task 4 and Q9 show that spatial arrangement and visual complexity interact significantly with color and contrast to influence older adults' overall perception of their surroundings. The degree of visual clutter in the area had a substantial impact on participants' comfort and ease of navigating, even when door colors were kept constant. Most participants favored the moderately cluttered environment, which offered visual context without overpowering the sightlines, whereas none preferred the highly cluttered condition. This shows that color and contrast do not work in isolation. Thus, how well a door color supports navigation depends on the visual environment surrounding it. A color that stands out clearly in a simple, open space may become harder to identify in a cluttered one, where competing elements draw the eye and reduce the door's visibility. Designers should therefore think about color and contrast alongside the overall complexity of the space not as separate decisions, but as part of the same visual system.

Design Recommendations

Based on the findings of this study and their alignment with the existing literature, the following evidence-based recommendations are offered for interior designers, architects, and facility managers working on spaces that serve older adult populations. These recommendations address door color selection, contrast specification, environmental clutter management, and future VR-based research methodology.

Recommendation 1: Prioritize Dark, Saturated Door Colors Against Light Wall Surfaces

The study's most immediate design recommendation is to utilize dark, saturated colors for door surfaces in interior places that older adults visit, especially when light-toned wall surfaces are present. The contrast sensitivity literature supports dark blue (such as navy, Hex: #1E3A5F or similar) as a consistently high-luminance contrast option against pale backgrounds, and it showed the best performance and preference in this investigation. Designers should use a luminance contrast ratio calculator such as the WCAG 2.1 contrast ratio tool or a similar instrument, to ensure that the chosen door color has a contrast ratio of at least 3:1 against the adjacent wall surface, with a ratio of 4.5:1 or higher recommended for spaces serving users with significant visual impairment. These thresholds align with both the physiological studies on contrast sensitivity decline in older adults (Derefeldt et al., 1979; Sia et al., 2013) and the accessibility standards mentioned in Chapter I.

Green likewise performed consistently in this study, with zero errors and no reported confusion. If the luminance contrast against the wall surface is adequate, medium to deep green could be a good substitute for navy blue for designers who like a warmer or more natural color scheme. The degree of luminance contrast between the door and wall, rather than the exact color, is the crucial factor that most directly affects older adults' ability to detect and identify the door from a distance in a corridor.

Recommendation 2: Avoid Bright Yellow on Light or Warm-Toned Wall Surfaces

This study clearly demonstrates that bright yellow doors should not be used as primary color identifiers in interior spaces with light, pastel, or warm-toned wall surfaces. The age-related yellowing of the crystalline lens described by Ishihara et al. (2001) and Suzuki et al. (2005) is an anticipated result of the perceptual blending seen in this study, when yellow doors were reported as appearing white against cream walls. This physiological alteration impairs older adults' capacity to distinguish between yellow and similarly pale surfaces, regardless of how visually striking the combination seems to designers studying samples under normal lighting circumstances. If yellow is required, for example, as part of a branding or institutional color scheme, designers should ensure that the wall surface closest to the door is much darker or cooler in tone to produce adequate luminance contrast. The contrast between a yellow door and a wall that is charcoal, dark green, or mid-grey would be quite different from that of a yellow door against cream. Alternatively, yellow can be used as an accent color in combination with another more reliably visible primary identifier, rather than as the sole color cue for door identification.

The recommendation is especially significant given the extensive use of yellow as a high-visibility color in accessibility literature. The results of this study indicate that the context in which yellow is used should be taken into consideration when making this suggestion. Without considering the unique surface interactions and lighting conditions found in the actual space, designers should not depend solely on general color guidelines.

Recommendation 3: Design for Moderate Visual Complexity Rather Than Minimal Clutter

The conclusion that participants preferred and moved more readily in a moderately cluttered environment rather than a open space raises questions regarding the widely held belief that minimalism is always preferable in older adult settings. While extremely cluttered rooms were completely avoided, depriving a space of all furniture and visual interest tends to impair the sense of familiarity and comfort that older adults associate with well-used, functional spaces. Designers should aim for an acceptable level of visual complexity that represents the places that older adults are familiar to and can confidently navigate, as well as the actual function of the space. In practical terms, this involves arranging furniture in a way that is both purposeful and well-organized, with good sightlines from common seating locations to important locations, especially entrances and exits. Furniture should be arranged to facilitate visual access to the door rather than to obstruct it, and the spatial arrangement should appear unified and planned rather than sparse or cluttered. This idea is strengthened by Li and Klippel's (2016) discovery that environmental readability, rather than simplicity, is the most effective indicator of navigation performance. When it comes to how easily and confidently older adults can travel and occupy a place, a carefully furnished area with a clear, readable layout will perform better than both a cluttered and an excessively sparse one.

Recommendation 4: Evaluate Color and Contrast as an Integrated System

The fact that color and contrast interact with spatial complexity, furniture arrangement, lighting, and the space's overall visual environment is one of the study's most important findings. Depending on the surrounding visual context, a door color that is easily recognizable in one setting could be challenging to recognize in another. Therefore, rather of viewing color and contrast choices as discrete decisions, designers should consider them as a component of an integrated visual system. In reality this involves assessing door color choices in light of the entire hallway or room environment, including the color of the walls, the floor, the type and quality of lighting, and the quantity and placement of furniture and décor. Mockups, renderings, or physical examples should be assessed in the space's actual lighting conditions and, preferably, examined with feedback from user advocates or older adult users. The particular mix of yellow against cream walls was the reason of yellow's constant failure in this study, not the color yellow alone. This result could not have been predicted by evaluating colors separately on a white example card. Designers working on places for older adults should be mindful that typical luminance contrast measurements may need to be exceeded in environments that serve users with more advanced visual changes. The literature reviewed in Chapter II indicates that meaningful design support for older adults may require contrast levels above the minimum contrast thresholds set by the ADA and Universal Design guidelines, which were not created specifically for the population under study (Pinheiro & da Silva, 2012a; van Buuren & Mohammadi, 2022b).

Recommendation 5: Incorporate Structured VR Orientation Periods in Future Research

This study emphasizes the need of including a controlled orientation time prior to task data collection for researchers utilizing VR as a platform to examine older adult navigation behavior. Seven out of ten participants in this study explained hesitancy during tasks related to interface confusion rather than visual design difficulty, and two-minutes free exploration period was insufficient for the majority of participants to gain complete comfort with the VR controller. Future studies should include a dedicated orientation phase of at least 5 to 10 minutes in which participants learn the specific navigation mechanics required for the study tasks, moving forward, turning, and approaching doors in a neutral environment before entering the study settings. This will greatly lessen the extent to which technology familiarity affects the relevant visual design findings and enable participants to gain interface confidence prior to their navigation behavior being recorded. VR has been shown by Cushman et al. (2008) to be an environmentally sound platform for research on older adult navigation; making sure that sufficient orientation time would improve the methodological rigor of investigations based on this foundation.

Limitations

Several limitations of this study should be recognized when interpreting and applying its results. Ten participants are a tiny sample size, which is a constraint. This sample size restricts the statistical generalizability of the quantitative results, even though it is suitable for an exploratory mixed-methods study and complies with the thematic saturation requirements outlined by Guest et al. (2006). The frequency counts and descriptive statistics presented in Chapter IV should not be interpreted as statistically representative results that apply to all older persons, but rather as patterns within a limited, targeted sample. To confirm and expand on these findings, future studies with bigger sample sizes and more varied participant groups including people from various cultural origins, with differing degrees of vision impairment, and over a wider age range are required. Second, even if the virtual environment is made to closely resemble the actual interior area, it is unable to completely imitate all of the sensory aspects of a real-world location. It is challenging to replicate aspects of real interior settings in virtual reality, such as lighting change, spatial depth perception, ambient sound, floor texture, and the physical sensation of movement. As several participants pointed out in Q13, comfort and preference responses may consequently differ somewhat from those that would be generated in the actual setting. Although it is positive that six out of ten participants agreed that the setting was close to the actual place, the three who said "somewhat" and the one who said "no" serve as a warning that virtual-to-real translation is not perfect. Third, this study only looked at three door colors; green, blue, and yellow along with three levels of environmental clutter; moderately cluttered, extensively cluttered and an open space. A more complete picture of how color choice affects older adult navigation would be possible with a greater variety of colors and contrast settings. Red-black combos, in particular, may be quite beneficial for older adults with cognitive impairment, according to the literature (Wang & Cho, 2022). A future study comparing these with the conditions examined here may provide useful comparison data. Fourth, the study relied on self-reported comfort and preference data, which are prone to response bias and personal interpretation. The brevity of several open-ended responses limited the amount of qualitative analysis feasible from the data, and participants may have answered in ways they felt were socially acceptable or expected rather than reflecting their actual experiences. To provide a more objective assessment of participant experience, future research may augment self-report measures with physiological markers of comfort or discomfort, such as heart rate variability or eye-tracking data.

Additionally, a public university's lifelong learning program, which self-selects for older adults who are active, interested in learning, and open to experimenting with new technology, was used to recruit the study group. This group could not accurately reflect older adults who are less accustomed to the interior spaces of institutions or who have more severe physical, cognitive, or visual impairments. Therefore, the results should be transferred most directly to comparable community-learning and educational settings, and care should be used when generalizing to healthcare, residential, or other institutional settings where the characteristics of the older adult population may change.

Conclusion

The purpose of this study was to look into how interior color and contrast tactics affect older persons' visual comfort, preferences, and navigation experience. The study produced precise and consistent results for each of the four themes it looked at using a mixed-methods approach that included post-navigation questionnaires, structured VR navigation exercises, and qualitative thematic analysis. Blue appeared as the most visually accessible and desired door color, with no navigation errors, the shortest mean completion time, and the highest preference ratings throughout the entire sample. Yellow created all ten incorrect door approaches in Task 3 and was found to be visually disturbing by several participants, making it the most difficult color to see. This conclusion is directly related to the age-related physiological changes reported in the literature. The majority of participants preferred the somewhat cluttered setting, indicating that older adults' comfort in an interior place is related to both visual clarity and a sense of spatial familiarity and intentional design. Together, these findings offer a meaningful contribution to the field of inclusive interior design. They demonstrate that color selection in older adult environments is not a matter of aesthetics alone, it is a functional decision with measurable consequences for how safely, comfortably, and confidently people can navigate the spaces they inhabit every day. Moreover, they demonstrate that although comfort and navigability are related, they are not the same thing, and that design approaches that focus on one without taking the other into account may not be able to fully satisfy the variety of needs that older adult users bring to an interior setting.

The recommendations provided in this chapter are supported by a wider collection of data found in the literature as well as the empirical results of this investigation. For designers working in educational, social, and institutional settings, they provide useful, practical guidance that goes beyond the basic needs of regulatory compliance and toward a more human-centered understanding of what it means to design for older adults appropriately. As the world's population ages, the demand for interior spaces that truly support older adults, not simply in their capacity to navigate, but also in their sense of comfort, familiarity, and dignity inside a space will continue to grow. This study represents a preliminary approach in establishing the evidence basis required to address that challenge. Transforming this preliminary evidence into long-lasting, validated design principles for aging populations worldwide will require future research that expands on these findings using larger samples, a wider range of color conditions, multisensory design variables, and real-world rather than virtual environments.

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APPENDIX A

Post-Navigation Survey and Data Collection Instrument

Virtual Reality Navigation Study

Study Space: Interior corridor environment within a public university building

VR Equipment: Meta Quest Pro headset

<u>SECTION 1: PARTICIPANT INFORMATION</u>

Participant ID: ____________________________________

Date of Session: ____________________________________

Age: __________

Gender: ☐ Female ☐ Male ☐ Non-binary ☐ Prefer not to say

Do you wear glasses or contact lenses?

☐ Yes ☐ No

Have you used a VR headset before?

☐ Yes ☐ No ☐ Not sure

How familiar are you with this building?

☐ Very familiar ☐ Somewhat familiar ☐ Not familiar

SECTION 2: NAVIGATION TASKS AND OBSERVATIONS

Coding guide: H = hesitation WD = wrong door WT = wrong turn C = corrected path

Task 1: Find a Specific Colored Door

Instruction: "Please find the [target color] door as quickly and accurately as possible."

Record

Target door color: ☐ Green ☐ Yellow ☐ Blue

Time taken: ____________________

Hesitation observed: ☐ Yes ☐ No

Number of wrong doors approached: __________

Notes: ____

Task 2: Find the Classroom You Usually Use

Instruction: "Imagine you are late for class. Please find the classroom you usually use as quickly as possible."

Record

Time taken: ____________________

Hesitation observed: ☐ Yes ☐ No

Wrong turns or wrong door approaches: __________

Did door color appear to help or hinder? ☐ Helped ☐ Hindered ☐ No clear effect

Notes: ____

Task 3: Locate Colored Doors in Order (Green → Yellow → Blue)

Instruction: "Please locate these doors in the following order: green, yellow, blue."

Record

3A – Green door

Time: ________________ **Hesitation:** ☐ Yes ☐ No **Wrong doors:** __________

3B – Yellow door

Time: ________________ **Hesitation:** ☐ Yes ☐ No **Wrong doors:** __________

3C – Blue door

Time: ________________ **Hesitation:** ☐ Yes ☐ No **Wrong doors:** __________

Overall notes: ____

Task 4: View Room Images and Discuss Preference

Instruction: "Please look at these room images and tell me which room you prefer and what makes it feel comfortable or uncomfortable."

Record

Preferred room: ______________________________

Reason for preference: ____

Comments (comfort, clutter, color, visibility, openness): __________________

<u>SECTION 3: POST-NAVIGATION SURVEY</u>

Ask the following questions after all navigation tasks are complete. Circle, check, or write the response.

A. Navigation Experience

1. How easy was it to find the doors you were looking for?

   ☐ Very easy ☐ Easy ☐ Okay ☐ Difficult ☐ Very difficult

2. Did you feel confused at any point during navigation? If yes, where or when?

   ____

3. Could you see the doors clearly from a distance as you walked down the corridor?

   ☐ Yes ☐ Somewhat ☐ No

4. Did you notice yourself pausing or hesitating while searching for the correct door?

   ☐ Yes ☐ No ☐ Not sure

B. Vision & Comfort

5. Were the door colors easy to see against the walls?

   ☐ Yes ☐ Somewhat ☐ No

6. Did the contrast between the walls, doors, and other elements help you locate the doors?

   ☐ Very helpful ☐ Somewhat helpful ☐ Not helpful

C. Color & Visibility

7. Which door color was easiest to see overall?

☐ Green ☐ Yellow ☐ Blue ☐ None stood out

8. Did any door color blend into the surroundings or cause confusion?

____

9. Which environment felt easiest to navigate?

☐ Open / minimal clutter ☐ Moderately cluttered ☐ Highly cluttered

10. Which room image did you prefer most, and why?

____

11. What made that room feel comfortable or uncomfortable to you?

____

D. Comfort Rating

12. On a scale of 1 to 5, how comfortable were your eyes during the experience?

☐ 1 – Very uncomfortable ☐ 2 ☐ 3 – Neutral ☐ 4 ☐ 5 – Very comfortable

13. Did this virtual environment feel similar to the real classroom space you usually use?

☐ Yes ☐ Somewhat ☐ No

Closing Question

Is there anything else you would like to share about the door colors, visibility, or comfort of the space?

APPENDIX B

Reference Space and Virtual Environment Comparison

Virtual Reality Navigation Study

This appendix presents photographs of the original interior corridor space at a public university building alongside images of the virtual environment developed for this study. The SketchUp-based virtual model was designed to replicate the spatial layout, brick wall surfaces, tile flooring, wall-mounted displays, and corridor proportions of the real space. Participants navigated the virtual environment during the study session using the Meta Quest Pro headset.

Part 1: Original Interior Space

The following photographs show the real interior corridor that served as the reference environment for the virtual model. Key spatial features including the brick wall surfaces, tile flooring, wall-mounted display panels, seating arrangements, and door positions were replicated in the virtual study environment.

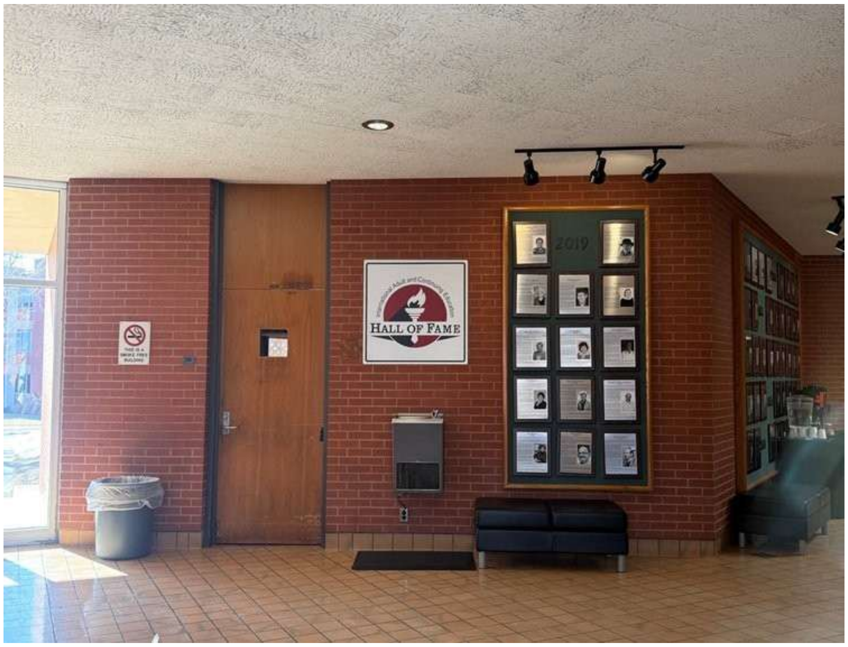

Figure 8: Corridor wall detail showing door position, brick wall texture, and the relationship between door and wall surfaces used as reference for the virtual environment. (Appendix B)

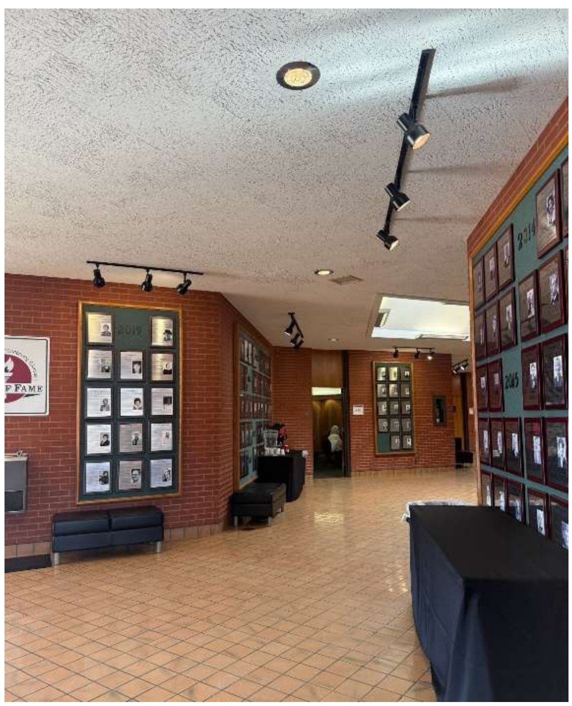

Figure 9: Full corridor view illustrating spatial depth, open layout, wall displays, and tile flooring replicated in the virtual model. (Appendix B)

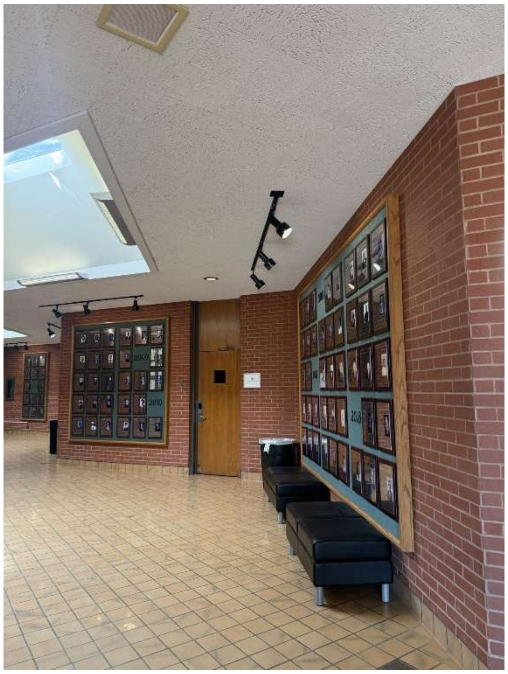

Figure 10: Corridor interior showing wall-mounted display panels, seating arrangements, natural and artificial lighting conditions, and door positions. (Appendix B)

Part 2: Virtual Environment Designed in SketchUp Model

The following images show the SketchUp-based virtual model developed for this study. The model replicates the corridor layout, brick wall texture, flooring, and wall display panels of the original space. Three door color conditions were incorporated; green (Hex: #228B22), blue (Hex: #1E3A5F), and yellow (Hex: #FFD700) which were applied against standardized light cream walls (Hex: #F5F5DC). The virtual environment also varied in visual clutter across the three-room pairs, representing high, moderate, and low clutter conditions.

Figure 11: Virtual environment showing green colored door against brick wall. (Appendix B)

Figure 12: Virtual corridor view showing door color conditions (green, blue, and yellow) visible simultaneously, illustrating the spatial layout and clutter levels used during navigation tasks. (Appendix B)