Journal of Accessibility and Design for All

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

ONE STEP CLOSER TO ACHIEVING INCLUSIVE DESIGN: DESIGN CONSIDERATIONS FOR CLIENTS WITH LOW-VISION

Ashley Hughes[1] and Shireen M. Kanakri[2]

Mississipie State University[1], Ball State University[2]

[1]lhughes@bsu.edu, [2]smkanakri@bsu.edu

Received: 2021-03-17 | Accepted: 2022-11-06 | Published: 2022-11-30

***Abstract*:** While the low-vision population in America continues to increase, few empirical studies have been completed investigating how environmental factors affect a low-vision person's ability to perceive the interior environment accurately. By using quantitative research methods to understand the critical relationship between contrast levels within the built environment and the ability of the low-vision and normal-sighted population to perceive that environment accurately, researchers can investigate safer and more inclusive interior spaces. Specifically, this study explores the environmental factor of contrast and how varying levels of contrast within interior spaces might affect the behaviour of low-vision participants within the interior environment. The findings demonstrate a preference among normal-sighted and low-vision participants for high-contrast environments, and their innate cues of high contrast.

Keywords: low-vision, interior design, contrast, accessibility, behaviour.

Introduction

Every design decision made throughout the design process can create a positive or negative experience within the interior built environment, especially for a person with low-vision relying on contrast and their other senses. Research has shown that it can affect the level at which they are willing to participate within that environment (Jenkins et al., 2015). As

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

designers, we strive to create an inclusively designed space to accommodate people with many different mobility, cognitive, visual and hearing ability levels; many professionals equate this to creating projects compliant with the Americans with Disabilities Act (ADA). However, these requirements favour those with mobility limitations, and only address issues of protruding objects and signage for the blind—it does little for those with limited vision (Sokol, 2007). The number of people with visual limitations is expected to increase by 6.31 million by the year 2020 due to the ageing population of baby boomers (Akpek & Smith, 2013) as well as those genetically predisposed to have low-vision. This drastic increase elevates the need for consideration in the design of interior spaces, specifically the contrast of finished materials, to allow this combined population of people to safely and independently navigate and participate in the built environment.

Low Vision

Low vision is defined as a visual impairment that makes everyday activities difficult, and that cannot be corrected with glasses or surgery (National Eye Institute, 2019). Low vision describes a severe loss of vision, which can be defined by a visual acuity level of 20/70 or worse after surgery has been performed, or corrective lenses have been worn (Dandona & Dandona, 2006). A person with a visual acuity level of 20/200 or worse is considered clinically blind. While low vision usually cannot be cured, advances in ocular medicine and technology can help to improve their quality of life. The four most common low-vision diagnoses are age-related macular degeneration, cataracts, diabetic retinopathy, and glaucoma (National Eye Institute, 2019). These diagnoses describe several symptoms and limitations that can be helped but not eliminated.

Inclusive Design

The inclusive design strives to go a step further than the Americans with Disabilities Act which provides requirements for how to make an interior environment accessible to people with mobility, visual, and hearing impairments (Nussbaumer, 2012). It strives to create an environment or product that integrates accessibility in a way that is seamless in design, with

functional requirements of the space for people of all abilities. Nussbaumer suggests the implementation of high-contrast, large text signage on the wall as a wayfinding method for people with low vision. But is there a way to combine this method with floor patterns and strategic lighting placement to reinforce, or highlight, the wayfinding system in a way that is helpful to all building occupants?

Sensory cues within the built environment

Sensory cues are one way to help people with low vision navigate the environment. Jenkins et al. propose that the environment plays a role in whether a person with low vision will take an active role in participating within that environment (2015). They also state the importance of understanding the sensory characteristics present that will help a person with low vision develop an understanding of the space in which they are attempting to work by providing accurate orientation cues, contributing to safe travel and wayfinding through the environment. Their study identifies three main themes discovered from the participant's survey responses discussing their experiences in multi-sensory environments: barriers, supporters, and context-dependence.

The barriers identified addressed environmental factors such as inconsistent lighting design, uneven floor surfaces and extreme sensory backgrounds. Supporters identified sensory characteristics in the built environment such as "audible cues and echoes, smells, tactile quality of the ground characteristics embedded in public spaces and the proximity to the sensory cues" (Jenkins et al., 2015, pp. 8644). The authors claim that these multisensory environments not only supported or inhibited a person with low vision activity participation level, but that it was also a context-dependent relationship, referring to the sensory cues of the environment and the activity being performed within the environment. This supports the belief that the environment in which a person with low vision occupies can affect that person's engagement level within the space. Therefore, careful consideration of finish materials could lead to more productive, comfortable and safe spaces.

Finish Materials

When a designer selects finish materials, there are many aspects to evaluate and consider, such as the composition of the material, the thickness of the material, what transition strips are available, the surface texture and light reflectance value, as well as where and how the product has been approved for use should also be considered. Schambureck & Parkinson's (2018) qualitative study outlines a typology system for designers to determine whether a space is a supportive or a non-supportive space for the low-vision population using four main categories: luminance contrast, value contrast, luminance placement, and object placement. Within the value contrast typology, detectable warnings, ghosting and deception typologies all relate to the amount of contrast needed within the interior environment for a person with low vision to develop spatial awareness and understanding.

Lighting

Lighting is another important environmental factor to consider when designing for the low-vision population. The standard measure of lighting levels is described in lux, which is defined as a "unit of illumination equal to the direct illumination on a surface that is everywhere one meter from a uniform point source of one candle intensity or equal to one lumen per square meter" (Merriam-Webster, n.d.). Most residences do not meet the recommendations for lighting levels provided by the Illumination Engineering Society of North America because they are too dim (Perlmutter et al., 2013). The literature currently does not address the needed lighting levels for people with low vision in commercial spaces, though it can be hazardous to have too much as well. Hotspots, or glares, can confuse a person with low vision (Barstow et al., 2011; Perlmutter et al., 2013). Lighting in transitional spaces can cause shock; going from a very bright exterior (65,000 - 130,000 lux) to a dim interior (37 – 59 lux) can happen in the span of ten seconds (Lasagno et al., 2014).

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Human Relation and Low-Vision Behaviors

A study conducted by Freedman et al. (2019) found that low-vision participants exhibited gaze behaviours toward the floor and wall boundary during navigation which served as a high contrast cue. This resulted in them missing the object and letter cues provided as the task during the observation experiment. This may provide insight into why many people with low vision look down while walking.

Other behaviours which may be exhibited by people with low vision when attempting to navigate the environment include eye blinking (Jones & Landa, 2011), poking or pressing the eyes (American Printing House for the Blind, 2019), slowing their walking pace, reaching for a wall while walking, stopping to ask for assistance (Hughes et al., 2018), or avoiding a space altogether (Jenkins et al., (2015). This study attempts to determine whether contrast in the interior space contributes to the exhibition of these behaviours by the low-vision population.

Methodology

Purpose of this Study

The main purposes of this research are:

- To understand how the contrast between finish materials in the interior environment impacts the behaviour of people with low vision.
- To generate design guidelines that will support the needs of these people with low vision.

Hypothesis

Hypothesis 1: There is a relationship between the contrast levels of interior finish materials and the accuracy of a person with low vision's perceptions of the interior environment.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Hypothesis 2: There is a correlation between the contrast of finish materials and the level at which a person with low vision is willing to participate within that environment.

Methodology for Phase I: Online Survey

Purpose

The first phase of this research study was an online survey for low-vision and normal-sighted participants to complete from the comfort of their own home or work environment. The main objectives of this survey were to assess the role that contrast played in a person's ability to accurately perceive the interior environment and to identify behaviours exhibited in an environment due to too-high or too-low levels of contrast. The survey instrument can be found in Appendix A.

Participants

The researcher set forth the goal of obtaining 100 low-vision and 100 normal-sighted participants' survey responses. Due to the location of the Phase II, getting more than 10 – 15 low-vision participants would be difficult, so the large number of survey responses would provide valuable data for analysis. Recruitment of participants

Data collection was conducted from August 20, 2019, to October 10, 2019. The survey was approved by the Mississippi State University Institutional Review Board for Human Subjects on August 19, 2019.

Instrument

The Phase I Survey consisted of 32 questions which addressed the impact of contrast levels within the interior environment on both people who are normal-sighted and those that have low vision. Six additional questions addressed the participant's demographic information, and low-vision participants were also asked for comparative analysis. The survey identified the preferred level of contrast present in the interior environment, and

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

behaviours associated with too high or too low levels of contrast. A five-point Likert scale was used for participants to rank the importance of contrast in the interior environment, with photographs illustrating the principle in question where appropriate. Participants were also asked to identify behaviours they exhibited in environments with too little or too high contrast levels, with a final open-ended question provided to add any additional behaviours not addressed in the survey. The survey instrument can be found in Appendix A. For low-vision participants, the survey was made accessible via voice-to-text answers and its ability to be easily read and described.

Procedure

The National Research and Training Center for Blindness and Low Vision located at Mississippi State University agreed to distribute a research announcement via email to their database, consisting of over 400 low-vision members. The National Federation for the Blind also reviewed, approved, and agreed to distribute the survey electronically to its national member database. This allowed the study to include a much larger number of potential research participants and gave more valuable data for analysis. This also helped to overcome the rural location of the researcher; a wider range of participants could respond, low-vision participants didn't need to worry about transportation. A reminder-to-respond email was sent out two weeks after the initial announcement encouraging responses, which doubled the number of surveys collected. Participants with normal vision were recruited through the snowball recruitment technique using Facebook, Twitter, and word-of-mouth. A link was provided via the posts connecting to a Qualtrics survey with the 'prevent ballot box stuffing' feature to ensure each participant answered only once.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Methodology for Phase II: Virtual Reality Behavioural Observation

Purpose

Phase II consisted of an observation study utilizing a virtual reality environment to investigate the preferred level of contrast present in the interior environment for a small low-vision and normal-vision population within a controlled setting. A single room was modelled; the finish materials on the wall and floors were changed to show nine different study environments, Figure 1.

Figure 1. Shows the virtual reality equipment setup at the lighting lab in Mississippi State University's Interior Design Program.

Participants

Purposeful sampling was utilized for this study, as both normal and low-vision participants are needed. Visual acuity levels between 20/20 and 20/70 were classified as normal-sighted, and participants with a visual acuity level between 20/70 and 20/1000 were categorized as low-vision. The sampling resulted in a combination of 17 low-vision and 17 normal-sighted participants.

Recruitment of Participants

Data collection was conducted from October 3, 2019, to October 20, 2019. The observation was approved by the Mississippi State University Institutional Review Board for Human Subjects on August 19, 2019.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Site Selections

Phase II was conducted in multiple locations in rural Mississippi in order to reach a larger number of participants with vision impairments. This also helped to alleviate the risk associated with travel for some participants with vision impairments and made participating in the study more convenient.

Site Selection A

The first study site selected was the 10-foot by 20-foot lighting laboratory with no windows of the Interior Design Program at Mississippi State University. The walls were painted eight different colours with divider strips separating each colour and tackable cork strips; an art piece hangs on the right wall and a mirror hangs on the front wall. HTC Vive sensors were placed in the front right and back left corners of the room to establish boundaries; a table and chair, a monitor, the HP backpack computer, and virtual reality goggles were located at the back of the room. A total of 10 participants were observed at this location.

Site Selection B

The second study site selected, shown in Figure 2, was a Sunday school room at Beersheba Church in Columbus, MS. This rectangular room was 18 feet by 26 feet with eight windows and two doors. HTC Vive sensors were placed in the front right and back left corners of the room to establish the room's boundaries. The same equipment listed above was located on the right side of the room. A total of 16 participants were observed at this location.

Figure 2. Shows Beersheba Church's Sunday school room with virtual reality equipment.

Site Selection C

The third study site selected, Shown in Figure 3, was an open area in a fellowship hall at First Presbyterian church in Louisville, MS. This rectangular area was 16 feet by 30 feet with two windows in the study area. HTC Vive sensors were placed in the front right and back left corners of the room to establish the room's boundaries. The same equipment listed above was located on the right side of the room. A total of 8 participants were observed at this location and this was the only site where all observations were completed in one day.

Figure 3 Shows the study area in First Presbyterian Church's Fellowship Hall with VR equipment.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

The observation documented preferred contrast levels between floor, base, and wall materials as well as behaviours exhibited by participants through behavioural frequency recordings in each location, Appendix B.

Study Environments

Since this study aimed to pinpoint the preferred level of contrast desired by people with low vision in wall to wall and floor to floor transitions, nine different study environments were created to obtain feedback from research participants. Each study environment was classified as a high, medium, or low-contrast environment by collecting the light reflectance values of the wall and floor materials and using subtraction to determine the difference between them (Schambureck & Parkinson, 2018). The following number ranges were used to determine the classification of low, medium and high contrast environments: High (30 – 45), Medium (15 – 29.9), Low (0 – 14.9). Scenes that feature a light wall and floor material were categorized as a low-contrast environment while scenes featuring a light wall with a dark floor were categorized as a high-contrast environment, and scenes with a combination of light wall materials and medium floor materials were categorized as a medium contrast environment.

Study Environment A

This environment features the lightest grey wall paint with the lightest carpet selection as seen in Figure 4. The specific finish material selections are indicated in Table 1. This environment will be classified as a low-contrast environment for the purposes of this study.

Figure 4. Illustrates study environment A's finish material placement and design.

Table 1. Study Environment A Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7064 Passive
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Limit 64515

Study Environment B

This environment features the lightest grey wall paint with medium-dark carpet selection, and a medium grey base material is located at the wall-to-floor transition material as seen in Figure 5. The specific finish material selections are indicated in Table 2. This environment will be classified as a medium-contrast environment for the purposes of this study.

Figure 5. Illustrates study environment B's finish material placement and design.

Table 2. Study Environment B Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7064 Passive
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Verge 64555

Study Environment C

This environment features the lightest grey wall paint with the darkest carpet, and a medium grey base material is located at the wall-to-floor transition selection as seen in Figure 6. The specific finish material selections are indicated in Table 3. This environment will be classified as a high-contrast environment for the purposes of this study.

Figure 6. Illustrates study environment C's finish material placement and design.

Table 3. Study Environment C Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7064 Passive
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Fringe 64585

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Study Environment D

This environment features the medium grey wall paint with the lightest carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 7. The specific finish material selections are indicated in Table 4. This environment will be classified as a medium-contrast environment for the purposes of this study.

Figure 7. Illustrates study environment D's finish material placement and design.

Table 4. Study Environment D Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 9163 Tin Lizzie
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Limit 64515

Study Environment E

This environment features the medium grey wall paint with the medium dark carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 8. The specific finish material selections are indicated in Table 5. This environment will be classified as a low-contrast environment for the purposes of this study.

Figure 8. Illustrates study environment E's finish material placement and design.

Table 5. Study Environment E Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 9163 Tin Lizzie
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Verge 64555

Study Environment F

This environment features the medium grey wall paint with the darkest carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 9. The specific finish material selections are indicated in Table 6. This environment will be classified as a medium-contrast environment for the purposes of this study.

Figure 9. Illustrates study environment F's finish material placement and design.

Table 6. Study Environment F Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 9163 Tin Lizzie
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Fringe 64585

Study Environment G

This environment features the darkest grey wall paint with the lightest carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 10. The specific finish material selections are indicated in Table 7. This environment will be classified as a high-contrast environment for the purposes of this study.

Figure 10 Illustrates study environment G's finish material placement and design.

Table 7. Study Environment G Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7674 Peppercorn
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Limit 64515

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Study Environment H

This environment features the darkest grey wall paint with the medium-dark carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 11. he specific finish material selections are indicated in Table 8. This environment will be classified as a medium-contrast environment for the purposes of this study.

Figure 11. Illustrates study environment H's finish material placement and design.

Table 8. Study Environment H Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7674 Peppercorn
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Verge 64555

Study Environment I

This environment features the darkest grey wall paint with the darkest carpet selection, and a medium grey base material is located at the wall-to-floor transition. as seen in Figure 12. The specific finish material selections are indicated in Table 9. This environment will be classified as a low-contrast environment for the purposes of this study.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Figure 12 Illustrates study environment I's finish material placement and design.

Table 9. Study Environment I Finish Materials

Finish Location	Manufacturer/Style	Color
Wall Finish	Sherwin Williams	SW 7674 Peppercorn
Base Finish	Johnsonite	28 Medium Grey
Floor Finish	Shaw Contract/Minimal	Fringe 64585

Instrument

Throughout the observation the researcher tallied each time a studied behaviour was observed on the Behavior Observation form, which lists each behaviour in chart form. After this walkthrough, the participants were asked to rank the environments in which they saw best. The rankings were recorded on The Study Environments Ranking form, Appendix C; a one for most preferred and three for the least preferred.

Procedure

Phase II consisted of an observation study which utilized a virtual reality environment to investigate the preferred level of contrast present in the interior environment, and behaviours exhibited within that environment for a small low-vision and normal-sighted population within a laboratory setting. A single room was modeled three-dimensionally on the computer, and the finish materials on the wall and floors were changed to reflect the nine different

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

study environments. A piece of art was modelled on one wall, and a chair was digitally placed in the middle of the room.

This observation utilized virtual reality technology, which most research participants were unfamiliar with, so detailed instructions and were given prior to placing the virtual reality goggles on the participant's head while a few minutes of acclimation were given after. The researcher explained that the room was empty other than the VR equipment, and that the chair shown in the virtual reality room was not actually present at the study site.

Once the study began, the researcher placed the participants at the back of the room and gave them instructions to walk to the front of the room and touch the piece of art shown on the wall. In order to do this, the participant was required to walk around the chair shown in the middle of the virtual reality environment. After touching the piece of art, they were asked to return to the back of the room. The researcher asked the participant to complete this each time she switched the study environments. The researcher was observing whether the participant could complete this task while recording the frequency in which any of the observed behaviours were exhibited. The researcher used a printed behavioural frequency chart located in Appendix B, and tallied each behaviour exhibited while also noting which environment the behaviour was exhibited within.

After completing the walkthrough of each study environment, the researcher presented each of the nine environments in groups divided by wall colour. The light grey wall grouping consisting of study environments A, B, and C was shown first. The participant was asked to identify the study environment that they saw best in, and then the environment that they had the hardest time seeing in. The same procedure was completed for the medium and dark wall groupings. After reviewing all nine study environments and selecting the best and worst environments for each of the three groupings, the researcher cycled through all 9 environments and asked the participant to select the study environment that they saw the best in, recording their responses on the Environment Ranking form found in Appendix C. Observations were video recorded to verify the researcher's notes, and lasted twenty minutes or less per participant.

Measurement Techniques

Behavioural observations of the research participants were based on the literature review, a previously conducted observational study, and the results of the survey from Phase I of this research.

Coding the Participants

A three-digit code was assigned to each participant to de-identify them, and protect their privacy. Once each participant was coded, the researcher input the codes into the SPSS software.

Selecting and coding the observed behaviours

A total of 6 behaviours were observed, coded from A to F. Observed behaviours were selected due to literature reviews and accounts of previous observations by the researcher of low-vision research participants.

Behavior Definitions

The following behaviours were identified through literature and previous accounts of interactions with people with low vision:

- Eye blinking: An involuntary response that protects and hydrates the eye (Jones & Landa, 2011). Rapid eye blinking was observed by the researcher in previous observations with low-vision participants in environments described to be confusing by research participants.
- Slowing pace: During previous observations, research participants slowed their pace in an interior environment that was described as hard to navigate (Hughes et al. 2018).
- Stopping to touch the wall: While walking/wayfinding, a low-vision research participant may stop to reach for or touch the wall when they are unsure of their surroundings or having issues with depth perception due to a lack of contrast. Hughes et al.(2018) observed research participants in a low-contrast environment who repeatedly stopped and touched the wall when they were unsure of their surroundings.

- Stopping to ask for assistance or a guide: Hughes et al. (2018) also observed a low-vision research participant stop to ask for an assisted guide, as they were not confident in their perception of the space. This behaviour could include asking for help, asking for directions, or asking for a person to guide them to their desired location.
- Avoiding a space: Jenkins et al. (2015) suggest that the interior environment plays a role in whether a person with low vision will attempt to participate in the environment. They suggest that if a person with low vision cannot understand the environment in which they are in, they may leave or avoid entering that environment completely, or leave the space quickly after entering.
- Eye poking or pressing: Some people with visual impairments may repetitively poke their eyes with their fingers or press their eyes firmly. (American Printing House for the Blind, 2019)

Video Recording

Prior to conducting the observation, permission to video record the study was requested. If the permission was refused, the researcher took notes throughout the study including detailed descriptions of what was observed and discussed. If permission to video-record the observation was granted, then the observation was recorded in its entirety to verify the behaviour frequencies recorded were accurate, and the video was transcribed within a week from the time the study was completed before being deleted.

Virtual Reality Equipment

The researcher chose to test the hypothesis for this study by utilizing a virtual reality environment so that the research participants could experience different materials within the same room. The use of the virtual reality backpack computer allows the participant to move around the space freely without fear of tripping over any cords.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

HP Z VR Backpack Computer

For this observational study, the researcher utilized an HP Z Virtual Reality computer, which can be mounted in a stationary dock and connected to the VR goggle headset by a twelve-foot-long connection cord or attached to a backpack for a free roam experience (HTC, 2019). Portable batteries are stored in a holster in the backpack to provide power to the computer (Hewlett Packard, 2019). Once the application is opened, the researcher can toggle through each of the environments via the keyboard, and a monitor is connected so the researcher and research participant can see the same views simultaneously. The researcher chose to use the backpack computer as it would reduce the risk of participants tripping on a long cord. A research assistant held the backpack and followed the research participant so that they would have a more authentic experience while wearing the headset and travelling through the virtual reality environment without the weight or restriction of motion. This also allowed the research participant to provide assistance to the participant if needed.

HTC Vive Virtual Reality Headset System

The HTC Vive virtual reality headset system includes a headset, two room boundary sensors, and hand controls (HTC, 2019). The headset connects to three ports at the top of the computer system. It is powered by the portable batteries located within the backpack. Due to the simplistic nature of the study environment used for this research, the hand controls were not needed and therefore were not utilized.

Two room sensors were placed at approximately eight feet above the finished floor in two opposite corners of the room, and the room dimensions were synchronized with the SteamVR program. This allowed participants to move around the room naturally without the danger of running into any walls. If a participant reaches the sensor's established boundaries, the room's natural walls, the room scene goes away, and a blue grid appears warning the participant to stop.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Phase 1 Analysis and Results

Participant Demographics

A total of 240 people participated in Phase I of the study, of which 118 self-reported as low-vision and 122 self-reported as normal-sighted. 80% of participants were female, while 20% were male. The ages of the participants were reported as falling in the following groupings can be seen in Fig. 13 below. The racial composition of the participants can be seen in Fig. 14 below. Of the normal-sighted participants, 70 self-reported normal vision and 52 self-reported near-normal vision. The ages of the normal-sighted participants were reported as falling in the following groupings: 18-25 (n = 72); 26-35 (n = 14); 36-45 (n = 10); 46-55 (n = 6); 56-65 (n = 14); 65-75 (n = 6); 76 and older (n = 2); and Prefer not to answer (n = 0). 81% of participants were female, while 18% were male. The racial composition of the participants was comprised of 68.03% Caucasian/White, 27.87% African American/Black, and 4.1% other.

Of the low-vision participants, 48 self-reported a severe visual impairment, 43 self-reported a moderate visual impairment, and 27 self-reported a profound visual impairment. Low-vision participants reported a wide range of low-vision diagnoses, with the highest frequencies being optic nerve hypoplasia (n = 12), glaucoma (n = 11), macular degeneration (n = 10), retinitis pigmentosa (n= 9), and other diagnoses not listed (54). The ages of the low-vision participants were reported the same as above. Seventy-seven percent of participants were female, while twenty-two percent were male. The racial composition of the participants was comprised of 72.03% Caucasian/White, 16.18% African American/Black, 3.39% Hispanic and 8.4% other.

Comparison Groups

For the purposes of analysis, two groups of individuals were identified from the data based on the responses to the question; How would you identify your level of visual impairment? This survey item allowed for five response options: Normal Vision (20/12-20/25); Near Normal (20/30-20/70); Moderate (20/80-20/160); Severe (20/160-20/400); Profound (20/400 – 20/1000). The division

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

of the two groups was based on the definition of low-vision which requires a visual acuity level of 20/80 or higher to be considered low-vision. The first group included all individuals with normal and near normal vision (n = 122), and the second group included those with moderate, severe, and profound visual impairment (n = 118). For statistical purposes, this grouping provided two groups of near equal size and served as the independent variable for this study.

Because there was some concern that the independent variable as described above did not adequately measure the extreme differences along the continuum of visual acuity, a second grouping method was employed for purposes of additional analysis. This second grouping method restricted the sample to only those who either reported as having perfect vision versus those with severe or profound visual impairment. For this second grouping variable, the first group included all individuals with normal vision (n = 70), and the second group included those with severe and profound visual impairment (n = 75).

Scale Construction

For purposes of analysis, multiple constructs required robust measurement. This was achieved through the construction of the following six scalar measures: Contrast Level Importance Scale; High Contrast Importance Scale; Medium Contrast Importance Scale; Low Contrast Importance Scale; High Contrast Behavioral Reaction Scale; and Low Contrast Behavioral Reaction Scale. The Contrast Level Importance Scale can be found in Table 10a and Table 10b.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Table 10a. Survey Scale Composition

Contrast Level Importance Scale	
Q6	Please evaluate the importance of these aspects for you in the interior environment. Contrast levels within the interior environment is an important issue for a person with your level of vision.
Q7	Please evaluate the importance of these aspects for you in the interior environment. Contrast levels between wall and floor finishes is an important issue for a person with your level of vision.
Q11	Please evaluate the importance of these aspects for you in the interior environment. Contrast levels between floor finish materials at flooring transitions are an important issue for people with your level of vision.
Q15	Please evaluate the importance of these aspects for you in the interior environment. The contrast level of base materials from wall and floor finishes are an important issue for people with your level of vision.
Q19	Please evaluate the importance of these aspects for you in the interior environment. Contrast levels within a floor finish pattern is an important issue for people with your level of vision.
Q23	Please evaluate the importance of these aspects in affecting the behavior of people with your level of vision. Contrast levels within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Contrast Level Importance Scale	
High Contrast Importance Scale	
Q8	Please evaluate the importance of these aspects for you in the interior environment. High contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q12	Please evaluate the importance of these aspects for you in the interior environment. High contrast at flooring transitions is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q16	Please evaluate the importance of these aspects for you in the interior environment For people with low-vision. High contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q20	Please evaluate the importance of these aspects for you in the interior environment. High contrast within a floor finish pattern are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.
Q24	Please evaluate the importance of these aspects in affecting the behavior of people with your level of vision. High contrast within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Contrast Level Importance Scale	
Medium Contrast Importance Scale	
Q9	Please evaluate the importance of these aspects for you in the interior environment. Medium contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q13	Please evaluate the importance of these aspects for you in the interior environment. Medium contrast at flooring transitions is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q17	Please evaluate the importance of these aspects for you in the interior environment. Medium contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q21	Please evaluate the importance of these aspects for you in the interior environment. Medium contrast within a floor finish pattern are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.
Q25	Please evaluate the importance of these aspects in affecting the behavior of people with your level of vision. Medium contrast within the interior environment can

Contrast Level Importance Scale	
	affect the level in which people with your level of vision are willing to participate in that environment.
Low Contrast Importance Scale	
Q10	Please evaluate the importance of these aspects for you in the interior environment. Low contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q14	Please evaluate the importance of these aspects for you in the interior environment. Low contrast at flooring transitions is helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q18	Please evaluate the importance of these aspects for you in the interior environment. Low contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.
Q22	Please evaluate the importance of these aspects for you in the interior environment. Low contrast within a floor finish pattern are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.
Q26	Please evaluate the importance of these aspects for you in the interior environment. Low contrast within the interior environment can affect the level in which people with your level of vision are willing to participate in that

Contrast Level Importance Scale	
	environment.
High Contrast Behavioral Reaction Scale	
Q27	Please indicate whether you have exhibited the following behaviors in response to high levels of contrast in the interior environment. Blinking eyes in an attempt to understand the interior environment.
Q28	Please indicate whether you have exhibited the following behaviors in response to high levels of contrast in the interior environment. Slowing your pace while walking in an attempt to understand the interior environment.
Q29	Please indicate whether you have exhibited the following behaviors in response to high levels of contrast in the interior environment. Stopping to touch the wall while walking in an attempt to understand the interior environment.
Q30	Please indicate whether you have exhibited the following behaviors in response to high levels of contrast in the interior environment. Stopping to ask for assistance or a guide while attempting to navigate the built environment.
Q31	Please indicate whether you have exhibited the following behaviors in response to high levels of contrast in the interior environment. Pressing or poking eyes while attempting to understand the built environment.
Low Contrast Behavioral Reaction Scale	
Q32	Please indicate whether you have exhibited the following behaviors in response

Contrast Level Importance Scale	
	to low levels of contrast in the interior environment. Blinking eyes in an attempt to understand the interior environment.
Q33	Please indicate whether you have exhibited the following behaviors in response to low levels of contrast in the interior environment. Slowing your pace while walking in an attempt to understand the interior environment.
Q34	Please indicate whether you have exhibited the following behaviors in response to low levels of contrast in the interior environment. Stopping to touch the wall while walking in an attempt to understand the interior environment.
Q35	Please indicate whether you have exhibited the following behaviors in response to low levels of contrast in the interior environment. Stopping to ask for assistance or a guide while attempting to navigate the built environment.
Q36	Please indicate whether you have exhibited the following behaviors in response to low levels of contrast in the interior environment. Pressing or poking eyes while attempting to understand the built environment.

Table 10b. Light Wall Environmental Ranked "Hardest to see and accurately perceive the interior environment"

Normal Sighted	Environment A	Environment B	Environment C
Count	11	3	3
Percent within Grouping	64.7%	17.6%	17.6%
Visually Impaired			
Count	7	2	8
Percent within Grouping	41.2%	11.8%	47.1%
All Partipants Combined			
Count	18	5	11
Percent within Grouping	52.9%	14.7%	32.4%

The construction of all scales was based on the face validity of the items being grouped. To statistically validate the scalar measures, a test of internal consistency was conducted for each scale. These tests yielded Cronbach's alpha values that were sufficiently high, such that all six scales are considered reliable (See Table 11).

Table 11. Tests of Internal Consistency for Scalar Measures

Scale	α
Contrast Level Importance Scale	.84
High Contrast Importance Scale	.78
Medium Contrast Importance Scale	.69
Low Contrast Importance Scale	.74
High Contrast Behavioral Reaction Scale	.78
Low Contrast Behavioral Reaction Scale	.78

The resulting scores on the six scalar measures exhibited normal or near normal distributions. Measures of central tendency and variation for the six scales are outlined in Table 12.

Table 12. Descriptive Statistics for the Scalar Measures

Scale	Min	Max	*M*	*SD*
Contrast Level Importance Scale	6	30	22.3	4.9
High Contrast Importance Scale	5	25	19.1	4.0
Medium Contrast Importance Scale	5	25	17.3	3.4
Low Contrast Importance Scale	5	25	14.4	4.1
High Contrast Behavioral Reaction Scale	5	25	14.9	4.8
Low Contrast Behavioral Reaction Scale	5	25	16.0	4.8

Test of Statistically Significant Differences Between Groups

Full Sample Comparisons (Grouping Method I)

To determine whether there were differences between the two groups with regard to their preferences for, and behavioural reactions to, environments with varying degrees of contrast, independent-Sample T Tests were conducted for each scalar measure with the first independent variable that included all participants (n = 240). Statistically significant differences between the normal-sighted and visually impaired groups were found for three of the six scalar measures. For the Contrast Level Importance Scale there was a statistically significant difference in scores for the participants with visual impairments (M = 23.5 ± 4.9) and normal sighted (M = 21.2± 4.5) participants; t (238) = -3.80, p = 0.00. For the High Contrast Importance Scale there was a statistically significant difference in scores for participants with visual impairments (M = 20.0± 4.1) and normal sighted (M =± 3.8) participants participant; t (238) = -3.31, p = 0.00. These results indicate that participants that were visually impaired participant rated high contrast environments as having greater importance for their ability to accurately perceive the interior

environment. For the Low Contrast Importance Scale there was a statistically significant difference in scores for the participants with visual impairments (M = 13.4± 4.3) and normal sighted (M = 15.3± 3.7) participants; t (238) = 3.73, p = 0.00. These results indicate that normal-sighted participants rated low-contrast environments as having greater importance for their ability to accurately perceive the interior environment. The other three scalar measures did not yield statistically significant differences for the two groups, as seen in Tables 14 through 18.

Table 14. Test Statistics for the Behavioural Reactions to Differing Environmental Contrast Levels Grouping Method I

High Contrast	*n*	*M*	*SD*	*t*	*df*	*p*
Normal-Sighted	17	.06	.24	-1.87	32	0.07
Visually Impaired	17	.53	1.01			
Medium Contrast						
Normal-Sighted	17	.35	.70	-1.76	32	0.09
Visually Impaired	17	1.35	2.23			
Low Contrast						
Normal-Sighted	17	.24	.752	-1.414	32	0.17
Visually Impaired	17	.76	1.348			

Partial Sample Comparisons (Grouping Method II)

Additional Independent-Sample T Tests were conducted for each scalar measure with the second independent variable that included only those participants with perfect vision versus those with severe and profound visual impairment (n = 145). Statistically significant differences between these two groups were found for four of the six scalar measures. For the Contrast Level Importance Scale there was a statistically significant difference in scores for the participants with severe/profound visual impairments (M = 24.2± 4.7) and the participants with normal sight (M = 20.3± 4.6); t (143) = -5.03, p = 0.00. These results indicate that those with visual impairments attributed a higher

level of importance to contrast level, on average, than those with normal-sight. For the High Contrast Importance Scale there was a statistically significant difference in scores for the participants with severe/profound visual impairments (M = 20.4± 4.1) and participants with normal sight (M = 17.8± 4.0); t (143) = -3.90, p = 0.00. These results indicate that participants with visual impairments rated high contrast environments as having greater importance for their ability to accurately perceive the interior environment. For the Low Contrast Importance Scale there was a statistically significant difference in scores for the participants with severe/profound visual impairments (M = 12.7± 3.9) and participants with normal sight (M = 15.6± 3.4); t (143) = 4.77, p = 0.00. These results indicate that normal-sighted participants rated low-contrast environments as having greater importance for their ability to accurately perceive the interior environment. For the Low Contrast Behavioral Reaction Scale there was a statistically significant difference in mean scores for the participants with severe/profound visual impairments (M = 16.8± 4.3) and participants with normal sight (M = 14.8± 5.0); t (142) = -2.57, p = 0.01. These results indicate that participants with severe/profound visual impairments reported a higher number of behavioural reactions to low-contrast environments than did normal-sighted participants. The other two scalar measures did not yield statistically significant differences for the two groups, as indicated in Figs. 15 and 16.

Phase II Analysis and Results

Participant Demographics

A total of 34 people participated in Phase II of the study, of which 17 self-reported as low-vision and 17 self-reported as normal-sighted. 68% of participants were female, while 32% were male. The ages of the participants were reported as falling in the following groups: 18-25 (n = 3); 26-35 (n = 4); 36-45 (n = 6); 46-55 (n = 1); 56-65 (n = 7); 65-75 (n = 7); 76 and older (n = 5); and Prefer not to answer (n = 1). The racial composition of the participants was comprised of 88.2% Caucasian/White and 11.8% African American/Black.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Comparison Groups

For the purposes of analyzing the observational data, the same grouping methods as those used with the survey data were employed. Responses to Q4 provided the requisite information to divide the sample into two groups, normal-sighted and low-vision. The two groups were of equal size (n = 17), though the second grouping was restricted to sample only those who responded with near-perfect vision.

Behavioral Response Tabulations

Behavioural observations of participants' reactions to the three environmental contrast levels were tabulated. This was achieved through summing the total number of observed behavioural reactions to the three environmental contrast levels: Total Behavioral Reactions to High Contrast Environments; Total Behavioral Reactions to Medium Contrast Environments; and Total Behavioral Reactions to Low Contrast Levels. See Table 13 below.

Table 13. Beahvioral Response Tabulations

Total Behavorial Reactions to High Contrast Environments	Total Count
Normal-sighted	1
Visually Impaired	9
Total Behavorial Reactions to Medium Contrast Environments	
Normal-sighted	6
Visually Impaired	23
Total Behavioural Reactions to Low Contrast Environments	
Normal-sighted	4
Visually Impaired	13

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Test of Statistically Significant Differences Between Groups

Full Sample Comparisons (Grouping Method I)

To determine whether there were differences between the two groups of participants with regard to the mean number of observations recorded, Independent-Sample T Tests were conducted for each environmental contrast level. No statistically significant differences were found between the two groups on any of the environmental contrast levels (See Table 15). The results of the Independent Sample T tests and descriptive statistics for the three environmental contrast levels are outlined in Table 14.

Table 15. Test Statistics for the Behavioral Reactions to Differing Environmental Contrast Levels Grouping Method II

High Contrast	*n*	*M*	*SD*	*t*	*df*	*p*
Normal-Sighted	10	.00	.00	-2.31	16	0.04
Severe/Profound Impairment	8	.38	.52			
Medium Contrast						
Normal-Sighted	10	.00	.00	-2.39	16	0.03
Severe/Profound Impairment	8	2.00	2.7			
Low Contrast						
Normal-Sighted	10	.00	.00	-2.52	16	0.02
Severe/Profound Impairment	8	1.25	1.6			

Partial Sample Comparisons (Grouping Method II)

For the second grouping method of the independent variable, additional Independent-Sample T Tests were conducted for each of the three environmental contrast levels. Statistically significant differences were found across all three contrast levels (See Table 15).

Preference for Environmental Contrast Levels

Light wall environmental contrast preferences

Study environments A, B, & C were ranked by participants while wearing virtual reality goggles. Participants identified the environment which they could see best in, and the environment which was hardest to see in. Environment A (Fig. 4) was preferred by 23.5% of overall participants; 11.8% of normal-sighted participants, and 35.5% of low-vision participants. Environment B (Fig. 5) was the selected by 26.5% of overall participants; 35.3% of normal-sighted participants, and 17.6% of low-vision participants. Environment C (Fig. 6) was preferred by 52.9% of normal-sighted participants and 47.1% of low-vision particpants.

Study Environment A (Fig. 4) was selected as the hardest environment to see in by 64.7% of normal-sighted participants, while Study Environment C (Fig. 6) was identified as the hardest to see in by 47.1% of participants with low vision. Study Environment A (Fig. 4) was identified as the hardest environment to see in by 52.9% of all participants.

Medium wall environmental contrast preferences

Study environments D, E, & F were ranked by participants while wearing virtual reality goggles. Participants identified the environment which they could see best in, and the environment which was hardest to see in Environment D (Fig. 7) was preferred by 38.2% overall; 23.5% of normal-sighted participants, and 52.9% of low-vision participants. Environment E (Fig. 8) was preferred by 14.7% overall; 17.6% of normal-sighted participants, and 11.8% of low-vision participants. Environment F (Fig. 9) was preferred by 47.1% overall; 58.8% of normal-sighted participants and 35.3% of low-vision participants.

Study Environment D (Fig. 7) was selected as the hardest environment to see in by 58.8% of normal-sighted participants, while Study Environment F (Fig. 9) was identified as the hardest to see in by 52.9% of low-vision participants.

Study Environment D (Fig.7) was identified as the hardest environment to see in by 44.1% of all participants; see Table 17.

Table 17. Medium Wall Environment Ranked "Hardest to see and accurately perceive the interior environment"

Normal Sighted	*Environment D*	*Environment E*	*Environment F*
Count	10	4	3
Percent within Grouping	58.8%	23.5%	17.6%
Visually Impaired			
Count	5	3	9
Percent within Grouping	29.4%	17.6%	52.9%
All Participants Combined			
Count	15	7	12
Percent within Grouping	44.1%	20.6%	35.3%

Dark wall environmental contrast preferences

Study environments G, H, & I were ranked by participants while wearing virtual reality goggles. Environment G (Fig.10) was preferred by 52.9% overall; 52.9% of normal-sighted particpants, and 52.9% of low-vision participants. Environment H (Fig. 11) was the preferred environment by 23.5% of normal-sighted participants, and 11.8% of low-vision participants. Envrionment F (Fig. 9) was preferred by 23.5% of normal-sighted participants and 35.3% of low-vision participants.

Study Environment I (Fig. 12) was selected as the hardest environment to see in by 41.2% of normal-sighted participants and 52.9% of low-vision participants. Study Environment I (Fig. 12) was identified as the hardest environment to see in by 47.1% of all participants. See Table 18 below.

Table 18. Dark Wall Environment Ranked "Hardest to see and accurately perceive the interior environment"

Normal Sighted	*Environment G*	*Environment H*	*Environment I*
Count	4	6	7
Percent within Grouping	23.5%	35.3%	41.2%
Visually Impaired			
Count	5	3	9
Percent within Grouping	29.4%	17.6%	52.9%
All Partipants Combined			
Count	9	7	16
Percent within Grouping	26.5%	26.5%	47.1

Overall environmental contrast preference

Participants were asked to identify the environment that was easiest for them to see in and accurately perceive the interior environment while wearing virtual reality goggles. Environment A (Fig. 4) was the most preferred by 29.4% normal-vision participants and 35.3% of low-vision participants.

Discussion

This study investigated the preferred level of contrast between floor and wall finishes within a space for both normal-sighted and low-vision participants. The findings suggest a high contrast. However, designers should be careful when specifying dark floor colours, as they may cause people with low vision to have anxiety towards walking on those floors. This validates a study conducted by Hughes et al. (2018).

This study also investigated the effect of contrast levels within the interior environment on a person's behavior within that environment. Participants with severe/profound vision loss exhibited a higher number of behavioural reactions to contrast levels within the interior environment than normal-sighted participants who exhibited no behavioural reactions. Low-vision

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

participants exhibited the highest number of behavioural reactions in medium-contrast environments and the lowest number of behavioural reactions in high-contrast environments. Therefore, high-contrast environments proved to be the easiest to navigate while triggering the least number of behavioural reactions to contrast levels within the environment.

The knowledge gained through this study should be used to educate designers on the importance of designing environments with high levels of contrast between the wall and floor surfaces for purposes of navigation, as it is important for people of all visual abilities, especially for people with low vision.

Contrast Level Preferences: Phase I interpretations

For the Contrast Level Importance Scale there was a statistically significant difference in scores for the severely/profoundly visually impaired under Grouping Methods I and II. The results indicate that low-vision participants attributed a higher level of importance to contrast level, on average, than normal-sighted participants.

For the Low Contrast Importance Scale there was a statistically significant difference in scores for the participants with severe/profoundly visual impairments under Grouping Methods I and II. The results indicate that normal-sighted participants rated high contrast environments as having greater importance for their ability to accurately perceive the interior environment.

Contrast Level Preferences: Phase II Interpretations

The Phase II Observations results reveal that both normal-sighted and low-vision participants reported high contrast environments to be more helpful in their ability to accurately perceive the interior environment. This observation will allow future designers to create better spaces for study and concentration, while also considering those with and without visual impairments.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Environments with Light Colored Walls

Participants were asked to identify the environment that was easiest for them to see in and accurately perceive the interior environment while wearing virtual reality goggles. Overall, participants selected Environment C (Fig. 6), a high-contrast environment, as their preferred environment. Overall, participants reported Environment A (Fig. 4), a low contrast environment, as the hardest environment to see in. Some low-vision participants reported Environment C as the hardest environment to see in, stating that they are uncomfortable walking in rooms with very dark floors. These supported observations made by Hughes, Carroll, and Miller (2018).

Environments with Medium Colored Walls

Participants with normal-sight and visual impairments did not agree on a preferred environment. Normal-sighted participants selected Environment F (medium grey wall with dark grey floor), a medium contrast environment, as their preferred environment, while low-vision participants selected Environment D (medium grey wall, light grey floor), also a medium contrast environment, as their preferred floor. The same was true of the environments ranked hardest to see in. Normal-sighted participants reported Environment D (medium grey wall and light grey floor), a medium contrast environment, as the hardest environment to see in, while low-vision participants reported Environment F (medium grey wall with dark grey floor), a medium contrast environment, as the hardest environment to see in. Low-vision participants reported a preference for lighter floors and restated their unease of walking in rooms with very dark floors.

Environments with Dark Colored Walls

Overall, participants agreed Environment G (Fig. 10), a high-contrast environment, was their preferred environment. The participants also agreed that Environment I (Fig. 12), a low-contrast environment, was hardest to see in. Low-vision participants reported a preference for lighter floors and restated their unease of walking in rooms with very dark floors.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Behavior and Contrast

Phase I Interpretations

For the Low Contrast Behavioral Reaction Scale there was a statistically significant difference in mean scores for the participants with severe/profound visual impairment when Grouping Method II was employed. The results indicate that participants with severe/profound visual impairments reported a higher number of behavioural reactions to low-contrast environments than normal-sighted participants. The High Contrast Behavioral Reaction Scale did not yield statistically significant differences between low-vision and severe/profound visual impairments.

Phase II Interpretations

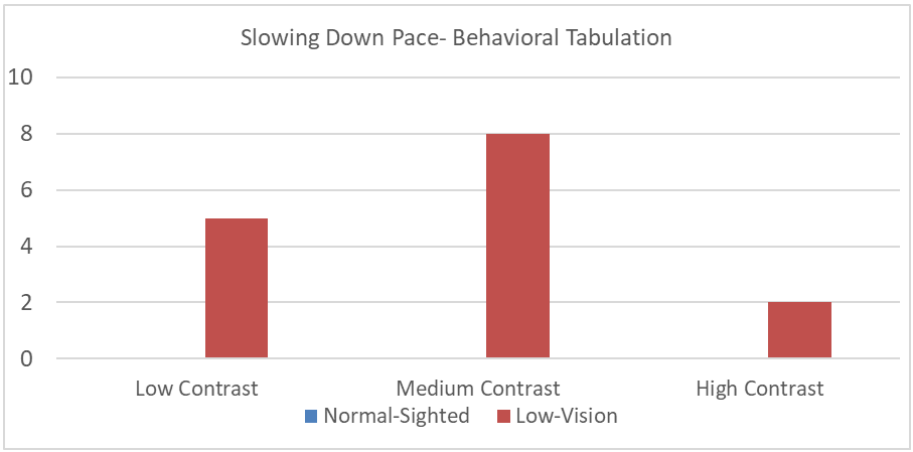
A statistically significant difference between mean scores for the participants with severe/profound visual impariments and those with normal-sight were found across all contrast levels when Grouping Method II was employed. The results indicate that participants with severe/profound vision exhibited a higher number of behavioural reactions to environments of all contrasts than normal-sighted participants. The mean scores suggest that low-vision participants exhibited the highest number of behavioural reactions in a medium-contrast environment and the lowest number of behavioural reactions in high-contrast environments.

Of the six studied behaviours, only three were exhibited by participants during the observations. These three observed behaviours included: Slowing down the pace while walking, Touching or reaching to touch the wall, and asking for assistance or guidance. Slowing down the pace while walking was exhibited a total of 15 times by low-vision participants, but was not exhibited by any normal-sighted participants. The environments in which low-vision participants exhibited the slowing down pace behaviour are broken down by the following environmental contrast levels: Low – 5; Medium – 8; and High – 2.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Slowing down the pace while walking was exhibited a total of 15 times by low-vision participants, but was not exhibited by any normal-sighted participants. The environments in which low-vision participants exhibited the slowing down pace behaviour are broken down by the following environmental contrast levels: Low – 5; Medium – 8; andHigh – 2. The results indicate that this behaviour is exhibited more times on average in medium-contrast environments than in low or high-contrast environments. Raising the level of contrast in a room may decrease the number of times this behaviour will be exhibited by people with low vision. See Figure 15 below.

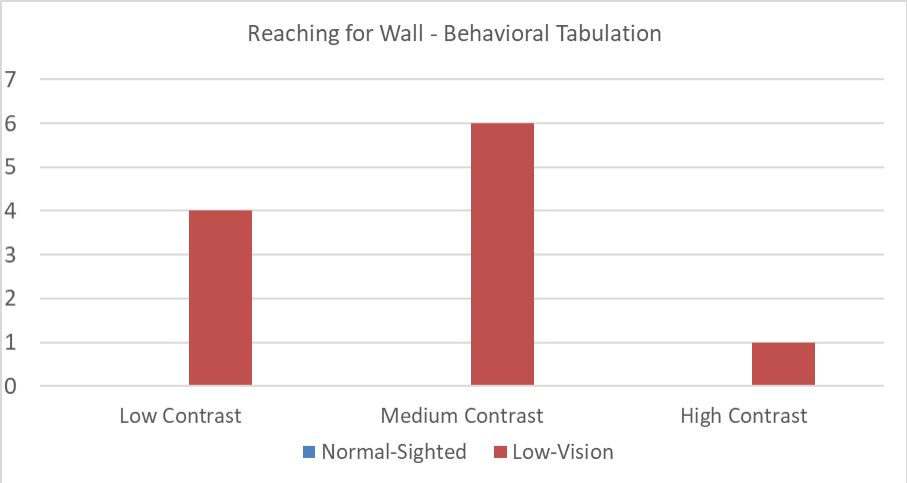
Figure 15. Illustrates participant's slowing down pace.



Reaching for or touching the wall while walking was exhibited a total of 11 times by low-vision participants, but was not exhibited by any normal-sighted participants. The environments in which low-vision participants exhibited the reaching for or touching wall behaviour are broken down by the following environmental contrast levels: Low – 4; Medium – 6; and High – 1. The results indicate that this behaviour is exhibited more times on average in medium-contrast environments than in low or high-contrast environments. Raising the level of contrast in a room may decrease the number of times this behaviour will be exhibited by people with low vision. See Figure 16 below.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Figure 16. Illustrates participant's reaching for wall frequencies.



Asking for assistance while navigating was exhibited a total of two times by low-vision participants, but was not exhibited by any normal-sighted participants. The environments in which low-vision participants asked for assistance are broken down by the following environmental contrast levels: Low – 1; Medium – 1; and High – 0. The results indicate that while this behaviour was exhibited in low and medium-contrast environments, the small frequency of exhibited behaviours prohibits the researcher from directly linking this behaviour to the contrast level within the environment.

Limitations of the Study

Research Type

While the quantitative research design gave the researcher access to a large quantity of data, the addition of qualitative interviews may have helped to provide additional explanations for why normal-sighted and low-vision participants preferred different environments.

Site Locations and Number of Observations

While the study was conducted at three different sites, it would be beneficial to expand the geographical location of the study sites to reach a larger number of low-vision and normal-sighted participants. Increasing the number of

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

observations would give more valuable data for analysis and expand the types of analysis that could be done.

Behaviours and Sample Size

The number of observations performed needs to be increased greatly in order to fully evaluate the behaviours exhibited within the environment on an individual basis. Because of the small number of low-vision participants (n = 17) and even smaller number of severe/profound low-vision visual acuity (n = 8), the number of observed behaviours was small, even though it was statistically different from the low-vision participants. The small sample size limited the analysis. A chi square test could not be performed on the behavioural reaction dataset because of the small sample size.

Behaviours and Virtual Reality Equipment

The inclusion of virtual reality equipment in this research project offered many benefits, but it did limit the researcher's ability to observe some studied behaviours. The HTC Vive Pro reality headset did not include the appropriate eye-tracking software to detect the first desired behaviour, rapid eye blinking. Therefore, this behaviour was not studied as part of this research.

Virtual Reality Observations

While the use of virtual reality equipment did allow the researcher to investigate many different finish combinations within the same interior environment while maintaining control over external factors associated with multiple study site locations, it is important to recognize that a virtual reality environment may not accurately emulate a real-world environment. The results of the study may not apply directly to the design of an actual interior environment.

Order Effect

The order each study environment was presented in was consistent from start to finish across all participants. This may explain why after viewing all nine study environments, the highest percentage of participants selected Study Environment A (light grey wall and light grey floor) as their preferred environment. This was inconsistent with the preference shown for high environmental contrast when evaluating three study environments grouped by wall colour at a time. The researcher suspects that this was a result of Study Environment A being the first environment seen after the least preferred environment, Study Environment I (dark wall, dark floor) was shown.

Conclusion

Future Studies

Future studies should be conducted to investigate the role of contrast between floor materials where transitions occur, and the role of contrast within flooring patterns and specifically carpet patterns. Are certain patterns more helpful? Are certain patterns less distracting? Are contrast levels within the patterns helpful or distracting? All of these questions are yet to be answered through empirical research.

While the findings of this study are compelling, they leave room for future investigation. A future study utilizing a higher number of participants and a more complex virtual reality environment could expand upon the connection of specific behaviour types and contrast levels of the environment.

Closing Statement

While the results of this body of research confirm the importance of designing an interior environment with high contrast between the wall and floor surfaces and links behavioural reactions to medium and low-contrast environments, there is still a gap in the body of knowledge regarding contrast in the interior environment and its effect on the low-vision population. More empirical research is needed within an environmental setting to investigate the role that

contrast plays within the interior environment on both the normal-sighted and low-vision populations.

References

[1] Akpek, E. K., Smith, R. A. (2013). Overview of Age Related Ocular Conditions. *The American Journal of Managed Care*. 19. 5. 67-75.

[2] Americans with Disabilities Act Accessibilities Guidelines. (ADA). (2010). Protruding Objects. Retrieved from https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/background/adaag#4.4

[3] Barstow. B. A., Bennett, D. K., & Vogtle, L. K. (2011). Perspectives on Home Safety: Do Home Safety Assessments Address the Concerns of Clients with Vision Loss? American Journal of Occupational Therapy. 65, 635- 642. doi: https://doi.org/10.5014/ajot.2011.001909

[4] Bochsler, T. M., Legge, G. E., Kallie, C. S. & Gage, R. (2012). Seeing Steps and Ramps with Simulated Low Acuity: Impact of Texture and Locomotion. *Optom Vis Sci*. 89. 9. E1299-E1307. doi: https://doi.org/10.1097/OPX.0b013e318264f2bd.

[5] Bradley, N. A. & Dunlop, M.D. (2005). An Experimental Investigation into Wayfinding Directions for Visually Impaired People. 9, 395-403. DOI: https://doi.org/10.1007/s00779-005-0350-y.

[6] Bright, K., Cook, G., & Harris, J. (1999). Building Design: The Importance of Flooring Pattern and Finish for People with a Visual Impairment. *The British Journal of Visual Impairment*. 17, 3,121-125.

[7] Creswell, J. W. (2017). *Research Design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: SAGE Publications Inc.

[8] Dandona, L., & Dandona, R. (2006). Revision of visual impairment definitions in the International Statistical Classification of Diseases. *BMC Medicine*, 4, 7. https://doi.org/10. 1186/1741-7015-4-7

[9] Freedman, A., Achtemeier, J., Baek, Y., & Legge, G. E. (2019). Gaze behavior during navigation with reduced acuity. *Experimental Eye Research*, 183, 20–28. https://doi.org/10.1016/j.exer.2018.11.002

[10] Golledge, R.G., Klatzky, R. L., & Loomis, J. M. (1996). Cognitive Mapping and Wayfinding by Adults without Vision. 215-246. Kluwer Academic Publishers.

[11] Hewlett Packard Development Co. (2019). HP Z VR Backpack. Retrieved October 21, 2019 from https://www8.hp.com/us/en/vr/vr-backpack.html.

[12] HTC Corporation. (2019). Vive VR. Retrieved October 21, 2019 from https://www.vive.com/us/product/vive-virtual-reality-system/.

[13] Hughes, A., Carroll, R., & Miller, B. (2019) *One Step Closer to Inclusive Design: Designing for Clients with Low Vision*. Interior Design Educators International Conference, March 6-9, Charlotte, NC.

[14] Jenkins, G.R., Yuen, H.K., & Vogtle, LK. (2015). Experience of Multisensory Environments in Public Space among People with Visual Impairment. *International Journal of Environmental Research and Public Health. 12*, 8644-8657; doi: https://doi.org/10.3390/ijerph120808644

[15] Khairallah, M., Khaloun, R., Bourne, R., Limburg, H., Flaxman, S., Jonas, J., et al. (2015). Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. *Investigative Ophthalmology & Visual Science*, 56, 6762–6769.

[16] Kobayashi, Y., Osaka, R., Hara, T., & Fujimoto, H. (2008). How Accurately People can Discriminate the Differences of Floor Materials with Various Elasticities. *IEEE Transactions on Neural Systems and Rehabilitation Engineering. 16*. 1.99-105.

[17] Lasagno, C. M., Issolio, L. A., Pattini, A. E., Colombo, E. M. (2014). Transitional spaces from exterior to interior as functional vision barriers in ageing. Lighting Res. Technology. 46, 706-715.

[18] Mayo Clinic. (2016). Glaucoma definition – Diseases and conditions. Retrieved from https://www.mayoclinic.org/diseases-conditions/glaucoma/symptoms-causes/syc-20372839

[19] National Eye Institute. (2019, July). Low-Vision. Retrieved October 16, 2019, from https://nei.nih.gov/learn-about-eye-health/eye-conditions-and-diseases/low-vision.

[20] Nussbaumer, L. (2012). Inclusive design a universal need. New York: Fairchild Books.

[21] Oaks, CA: Sage Publications. Jenkins, G.R., Yuen, H.K., & Vogtle, L.K. (2015). Experience of Multisensory Environments in Public Space among

People with Visual Impairment. *International Journal of Environmental Research and Public Health*. *12*, 8644-8657. doi: https://doi.org/10.3390./ijerph120808644.

[22] Perlmutter, M. S., Bhorade, A., Gordon, M., Hollingsworth, H., Engsberg, J. E., & Baum, M. C. (2013). Home lighting assessment for clients with low vision. *American Journal of Occupational Therapy*, 67, 674-682. http://dx.doi.org/10.5014/ajot.2013.006692

[23] Portugali, J. (1996). *The Construction of Cognitive Maps*. Netherlands. Kluwer Academic Publishers.

[24] Schambureck, E. & Parkinson, S. (2018) Design for Sight: A Typology System for Low-Vision Design Factors. *Journal of Interior Design*, 43(2), 33–54.

[25] Sokol, D. (May 2007). Baby Boomers Teeter on Edge of Vision Crisis. Architectural Record. 195. 5.

[26] Stelmack, J. A., Stelmack, T. R., & Massof, R. W. (2002). Measuring low-vision rehabilitation outcomes with the NEI VFQ-25. Investigative Ophthalmology & Visual Science, 43(9), 2859–2868.

[27] Watson, G. R. (2001). Low vision in the geriatric population: Rehabilitation and management. *Journal of the American Geriatrics Society*, 49(3), 317–330. https://doi.org/10.1046/j.1532- 5415.2001.4930317.x

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Appendix A: Survey Instrument

Demographic Information

1. What is your age?

   - 18-25
   - 26-35
   - 36-45
   - 46-55
   - 56-65
   - 66-75
   - 76 or older

2. What is your gender?

   - Male
   - Female
   - Prefer not to answer

3. What race do you most closely identify yourself with?

   - Caucasian/White
   - African American
   - American Indian
   - Hispanic
   - Other

4. How would you identify your level of visual impairment?

   - Near normal (20/30 – 20/70)
   - Moderate (20/80 – 20/160)
   - Severe (20/160- 20/400)
   - Profound (20/400 – 20/1000)

5. What is your low-vision diagnosis?

   - Diabetic Retinopathy
   - Temporal Arteritis
   - Corneal Transplant
   - Optic Neuritis

- Optic Nerve Hypoplasia or Nystagmus
- Central areolar choroidal dystrophy
- Coloboma or glaucoma
- Myopic Macular Degeneration
- Age-related Macular Degeneration
- Other, please identify:

  _____

Q6. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

a. Contrast levels within the interior environment is an important issue for people with your level of vision.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q7. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

b. Contrast levels between wall and floor finishes is an important issue for people with your level of vision.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with high contrast between wall and floor

Q8. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

c. High contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with medium contrast between wall and floor colors

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Q9. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

d. Medium contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with low contrast between wall and floor colors

Q10. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

e. Low contrast between wall and floor finishes is helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q11. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

f. Contrast levels between floor finish materials at flooring transitions are an important issue for people with your level of vision.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with high contrast at flooring transition

Q12. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

g. High contrast at flooring transitions is helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

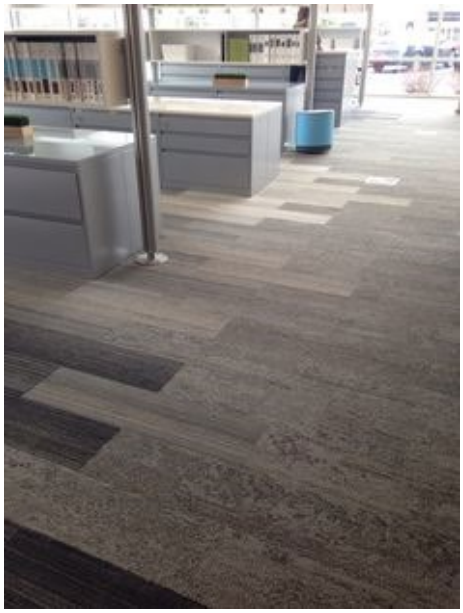


Image: Space with medium contrast at flooring transition

Q13. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

h. Medium contrast at flooring transitions is helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with low contrast at flooring transition

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Q14. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

i. Low contrast at flooring transitions is helpful in aiding a person your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q15. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

j. Contrast level of base materials from wall and floor finishes are an important issue for people with your level of vision.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with high contrast of base materials from wall and floor finishes

Q16. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

k. High contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with medium contrast of base materials from wall and floor finishes

Q17. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

l. Medium contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Image: Space with low contrast of base materials from wall and floor finishes

Q18. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

Q19. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

m. Low contrast of base materials from wall and floor finishes are helpful in aiding a person with your level of vision to accurately perceive the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q20. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

n. Contrast levels within a floor finish pattern is an important issue for people with your level of vision.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

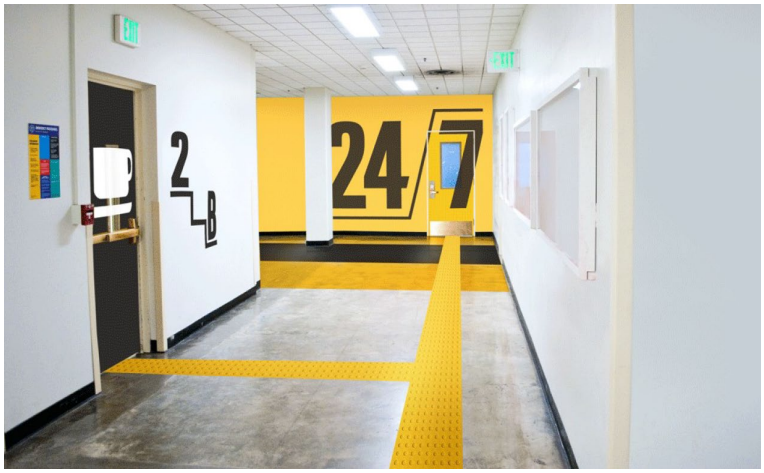


Image: Space with high contrast within floor finish pattern

Q21. Please evaluate the importance of these aspects of the interior environment for people with low vision.

o. High contrast within a floor finish patterns are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Image: Space with medium contrast within floor finish pattern

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Q22. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

p. Medium contrast within a floor finish patterns are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

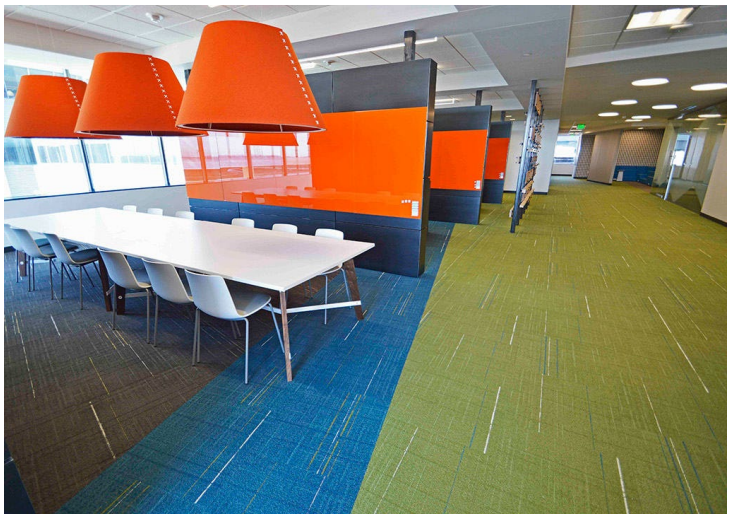


Image: Space with low contrast within floor finish pattern

Q23. Please evaluate the importance of these aspects of the interior environment for people with low-vision.

q. Low contrast within a floor finish pattern are helpful in aiding a person with your level of vision to accurately perceive the interior environment and aide in navigation.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q24. Please evaluate the importance of these aspects in affecting the behaviour of people with your level of vision.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

a. Contrast levels within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q25. Please evaluate the importance of these aspects in affecting the behaviour of people with your level of vision.

b. High contrast within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q26. Please evaluate the importance of these aspects in affecting the behaviour of people with your level of vision.

c. Medium contrast within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q27. Please evaluate the importance of these aspects in affecting the behaviour of people with your level of vision.

d. Low contrast within the interior environment can affect the level in which people with your level of vision are willing to participate in that environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Q28. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

a. Blinking eyes in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q29. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

b. Slowing your pace while walking in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q30. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

c. Stopping to touch the wall while walking in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q31. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

d. Stopping to ask for assistance or a guide while attempting to navigate the built environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q32. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

e. Pressing or poking eyes while attempting to understand the built environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q33. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

Q34. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

a. Blinking eyes in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q34. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

b. Slowing your pace while walking in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q35. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

c. Stopping to touch the wall while walking in an attempt to understand the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q36. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

d. Stopping to ask for assistance or a guide while attempting to navigate the built environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q37. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

e. Pressing or poking eyes while attempting to understand the built environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Q38. Please indicate whether you have exhibited the following behaviours in response to **low levels of contrast** in the interior environment.

f. Avoided a space due to lack of contrast in the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q39. Please indicate whether you have exhibited the following behaviours in response to **high levels of contrast** in the interior environment.

g. Avoided a space due to too much contrast in the interior environment.

Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat Agree	Strongly Agree
1	2	3	4	5

Q40. Please provide an answer to the following questions.

a. What types of behaviors have you exhibited due to contrast levels in the interior environment?

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Appendix B: Behavioural Observation Form

Participant #:

Observer:

A) Behaviours Observed:

B) Blinking Eyes

C) Slow down

D) Reaching for/touching the wall

E) Stopping to ask for assistance

Avoid/leave the space Behaviour Observed	**Environment/ Level of Contrast**	**Number of Occurrences**	**Totals**
A – Rapidly Blinking Eyes	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall-Comment** A. B. C.	**1. Light** A. B. C.
A – Rapidly Blinking Eyes	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.

Avoid/leave the space Behaviour Observed	Environment/ Level of Contrast	Number of Occurrences	Totals
A – Rapidly Blinking Eyes	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.
B- Slow Down Pace	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.
B- Slow Down Pace	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.
B- Slow Down Pace	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.

Avoid/leave the space Behaviour Observed	Environment/ Level of Contrast	Number of Occurrences	Totals
C -Touch the Wall	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.
C -Touch the Wall	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.
C -Touch the Wall	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.
D - Ask for assistance	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.

Avoid/leave the space Behaviour Observed	Environment/ Level of Contrast	Number of Occurrences	Totals
D - Ask for assistance	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.
D - Ask for assistance	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.
E - Avoid/Leave	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.
E - Avoid/Leave	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.

Avoid/leave the space Behaviour Observed	Environment/ Level of Contrast	Number of Occurrences	Totals
E - Avoid/Leave	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.
F- Poke or Press Eyes	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.
F- Poke or Press Eyes	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.
F- Poke or Press Eyes	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor I. Dark Wall/ Dark Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Appendix C: Study Environment Rankings Form

Participant #:

Observer:

Preferred Contrast Levels:	**Wall/Floor Conditions**	**Participant Comments**	**Preference Rankings**
Rank each study environment in order of preference with 1 being the most preferred and 3 being the least preferred.	**1. Light Wall** A. Light Wall/ Light Floor B. Light Wall/ Medium Floor C. Light Wall/Dark Floor I. Dark Wall/ Dark Floor	**1. Light Wall- Comments** A. B. C.	**1. Light** A. B. C.
Rank each study environment in order of preference with 1 being the most preferred and 3 being the least preferred.	**2. Medium Wall** D. Medium Wall/Light Floor E. Medium Wall/ Medium Floor F. Medium Wall/Dark Floor	**2. Medium Wall** D. E. F.	**2. Medium** D. E. F.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

Preferred Contrast Levels:	**Wall/Floor Conditions**	**Participant Comments**	**Preference Rankings**
Rank each study environment in order of preference with 1 being the most preferred and 3 being the least preferred.	**3. Dark Wall** G. Dark Wall/Light Floor H. Dark Wall/ Medium Floor	**3. Dark Wall** G. H. I.	**3. Dark** G. H. I.

Volume 12, Issue 2. (CC) JACCES, 2022. ISSN: 2013-7087

How to cite this article:

Hughes, A.& Kanakri, S.M., (2022). One step closer to achieving inclusive design: design considerations for clients with low vision, 12(2), 212-283. Journal of Accessibility and Design for All. https://doi.org/10.17411/jacces.v12i2.331

The Journal of Accessibility and Design for All, ISSN 2013-7087, is published by the Universitat Politècnica de Catalunya, Barcelona Tech, with the sponsoring of Fundación ONCE. This issue is free of charge and is available in electronic format.

JACCES is committed to providing accessible publication to all, regardless of technology or ability. The present document grants strong accessibility since it applies to WCAG 2.0 and accessible PDF recommendations. The evaluation tool used has been Adobe Acrobat® Accessibility Checker. If you encounter problems accessing the content of this document, you can contact us at jacces@catac.upc.edu.