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Exploring textures in enhancing spatial perception for visual impairment people

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ABSTRACT

EyeSight is one of the important senses for us to keep in touch with our surroundings. People with visual impairment always rely on their sensory perception to interact with spatial environments. Textured surfaces can be used to create a sense of movement. And yet, visual impairment poses significant challenges to spatial perception and navigation. Hence, there remains a gap in understanding the standard exploration of spatial qualities to evaluate the efficiency of textures in enhancing spatial perception. The research methodology involves qualitative methods by researching the case studies and interview sessions with visually impaired people and the staff from the Malaysian Association for the Blind (MAB). Research findings throughout the study highlight the importance of texture characteristics in facilitating spatial perception. It explores the interaction between tactile textures and sensory modalities for visually impaired people. This research aims to investigate the utility of textures in the interior in enhancing spatial perception for visually impaired people. Also, this research explores the application of varied textures to be used in the interior for visually impaired people. The findings are important for determining the best texture for the enhancement of spatial perception for visually impaired people.

Introduction

Visions have played some dominant roles in human life. A person's visual ability is at risk at any age. It is estimated that approximately 2.2 billion people are blind or have a vision impairment globally, with at least 1 billion of those suffering from preventable vision impairments or unaddressed vision impairments (World Health Organization 2019). For a long time, design has neglected other human senses in favor of the visual sense. Designing for multiple senses can greatly enhance the overall experience and accessibility of a space, especially for visually impaired individuals. By incorporating elements such as tactile textures, auditory cues, and olfactory stimuli, interior designers can create environments that engage and stimulate multiple senses, providing a more inclusive and immersive experience for everyone (Spence 2020). In other words, individuals with visual impairments have significant challenges when perceiving and navigating spatial environments. In the absence of vision or with limited vision, a person's ability to comprehend space is greatly diminished, so alternative approaches are required to enhance the ability to perceive space.

Architecture is a multisensory field that incorporates sound, aromas, colors, textures, and lighting in theory (Helmy Almaz 2022). Also, architects and interior designers in recent decades have begun considering other senses in their designs (Nizam and Talib 2024). Thus, suitable materials are used to design a building's interior

space. Navigational cues and braille are provided in most of the public buildings around the world. Through the use of tactile signage or embossed maps, those who are visually impaired can mentally map their surroundings and navigate with greater confidence and independence (Yoke Ting and Bahauddin 2022). People-centric design is achieved through a well-designed architectural space that emphasizes an emphatic approach (Abdul Kadir and Wilastrina 2023). However, much of the current literature on visual impairment pays particular attention to multi-sensory perception for visually impaired people. It often focuses solely on auditory or tactile stimuli (Wong and Zakaria 2025).

To communicate spatial information, textures, and tactile sensations offer a promising avenue of exploration, enabling visually impaired individuals to navigate their surroundings more effectively and independently. The significance of tactile perception in compensating for visual deficits has been recognized across various disciplines, including psychology, neuroscience, and assistive technology. Textures, such as raised patterns, embossed maps, and tactile paving, have been studied for their potential to represent spatial features and aid in orientation and mobility (Thung and Ahmad 2022). These studies are carried out to understand how interior design can be optimized to meet the needs of visually impaired individuals, ensuring that their environments are both functional and accessible. Thus, the objective of this study is to investigate the utility of texture in interior design for visually impaired people. Next, the research aims to explore the application of varied textures for visually impaired people.

Literature review

Spatial perception is a person's ability to perceive space taking into account both their relationships with their environment (exteroceptive processes) and their relationships among themselves (interoceptive processes) (Cognifit 2016). Different visual sensations will result from the items being displayed in various spatial senses. The work's shape, placement, and line of sight all constantly influence how a user perceives it Different visual sensations will result from the items being displayed in various spatial senses. The work's shape, placement, and line of sight all constantly influence how a user perceives it. The user may be drawn to a particular type of material when they see these materials, and the material's reflectance may have an impact on their emotions. The user may be drawn to a particular type of material when they see these materials, and the material's reflectance may have an impact on their emotions (Ren 2022).

An increasing amount of writing nowadays explains how perception is essentially multisensory. With the absence of vision, it is assumed that the multisensory of a person works along with other senses such as haptic, hearing, and olfactory to have a better understanding of space (Bakir et al. 2022). There is a deep multisensory comprehension of the work's significance developed by individuals with visual impairment was offered through the use of synesthesia (Cho 2021).

As we know, the spatial form and intrinsic artistic energy of installation art contribute to its aesthetic appeal, which elicits many reactions and interpretations from the observer. Nevertheless, an experiment shows the various senses of humans play a key role in a spatial experience, resulting in a relationship between people and places (Tarçın Turgay and Tunçok Sarıberberoğlu 2022). The distinction between what is firm, sharp, and distinct and what is soft, blurry, and fuzzy can be made by viewing distance rather than by distinguishing between organic and inorganic materials, as both scientists and artists are aware of. However, there is a lack of standard exploration to evaluate the efficiency of textures in enhancing spatial perception. It is obvious that a neccesity attention and act are badly needed, especially to the multi-sensory perception for visually impaired people.

The study found that respondents with vision impairment in multisensory environments comprised four sub-themes which are population-specific design, extreme sensory backdrops, uneven ground surfaces and items, and inconsistent lighting (Jenkins, Yuen, and Vogtle 2015). Thus, it is important to explore the senses of perception on texture through visual contrasts in spatial perception by people with visual impairments.

Exploring space through spatial perception was shown by the theory of J.J. Gibson’s Ground Theory of Space Perception. In Gibson's theory, the environment plays a crucial role in influencing perceptual experiences by emphasizing texture gradients, horizon lines, and invariant properties (Sedgwick 2021). Hence, texture is one of the important elements to be considered when designing the interior of a building for visually

impaired individuals. It offers tactile feedback that can be sensed through touching. It is used in interior designs to enhance the appearance of the space. External and interior movements inside a building can be identified by its surface characteristics, especially with the wall textures (Helmy Almaz 2022). As such, a texture element is provided by different materials with different roughness, smoothness, softness, or firmness, and it can help for the visual impairment to classify between areas. By using textures strategically, it has created a multi-dimensional atmosphere that stimulates the senses and promotes a sense of balance and harmony (Gulri A. 2023).

Methods

In compliance with the objectives, research will be conducted using qualitative methodology by John Creswell, which includes literature review, data collection through interview sessions, generating interview questions, online and paper surveys.

Interview session

Primary data was collected by interviewing the targeted interviewees who are from the field of the profession for the visually impaired. Selection of the interviewees are the Ophthalmologist and the person in charge of the Research and Development department of the Malaysian Association for the Blind (MAB). Next, a total of 10 visually impaired people will be interviewed to get their sense of experience. The interviewees will be asked questions about their past experiences and the challenges they faced when going into a building. The findings from the interviews will then be analyzed and summarized.

Case studies

Case studies will be conducted in this research too. Through the analysis of these case studies, a better understanding of the application of texture in interior design helps to enhance the spatial perception of visually impaired people. The findings of the case studies will be used to develop recommendations for the use of texture in interior design. Additionally, the research will provide a better understanding of how texture can be used to create more accessible designs.

The case studies below were conducted to better understand the exploration of texture to be used for interior design for the visually impaired.

School of blind and visually impaired children, Gandhinagar, India

School of Blind and Visually Impaired Children is located in Gandhinagar, India. This simple geometrical building typology allows the students to create a mental map of the spaces. Light strokes and articulated volumes identify the corners, and the corridor surrounding the central plaza has varying widths and volumes.

Besides that, the ability to distinguish spaces is enhanced by contrasting colours and surfaces. Contrasting colours are utilized on the doors and furniture to make it easier for the low-vision students to identify the space. Light and shadow are created in contrasting areas through the use of specific skylights and openings.

Furthermore, the structure is created with varying ceiling heights and corridor widths. By creating an echo in the area which the steps lead, this design aids students in recognizing the location of the structure.

Figure 1. Section cut of the building of the school of blind and visually impaired children, Gandhinagar, India
Source: ArchDaily

Moreover, the building design has guided the students through the spaces by the materials and texture of the walls and floor. Both of the surfaces have a different contrast. The chosen flooring is a smooth Kota stone surface while the structure uses five distinct textures for the wall plaster. The corridor's shorter side contains vertical textures, whereas the longer side has horizontal ones. This leads the blind and visually impaired users to determine which side of the hallway they are on.

For the exterior, the wall is plastered with sand faces. However, the courtyard has a different texture with it.

Figure 2, 3, 4. Examples of wall texture applied in the building of The School of Blind and Visually Impaired Children, Gandhinagar, India
Source: ArchDaily

Based on the record, the contractor constructed mock-ups during the construction process and a few students experimented with various wall plaster textures to find the most suitable one.

LTA tactile paving system in Singapore

The Land Transport Authority (LTA) tactile paving system in Singapore is an integral component of the country's efforts to enhance accessibility and facilitate safe navigation for individuals with visual impairments. LTA has implemented tactile paving across various public spaces and transportation facilities to assist visually impaired pedestrians in identifying walking paths, hazards, and transit amenities.

The primary purpose of the LTA tactile paving system is to provide tactile cues that help visually impaired individuals navigate urban environments independently and safely. The design of tactile paving includes standardized patterns and colours to convey specific messages through touch.

Yellow tiles with raised dots indicate caution or potential hazards, such as approaching stairs, escalators, or platform edges at the LTA stations. The distinctive yellow color contrasts with the surrounding pavement, making it visually noticeable as well.

Next, blister patterns were placed in the MRT station in Singapore including circular studs (attention patterns) and elongated strips (guiding patterns). Tactile paving with blister patterns signifies safe pathways for pedestrians, guiding them along walkways, crosswalks, and transit platforms. These patterns are designed to be detectable by foot or cane, aiding in orientation and mobility.

LTA is constantly improving and growing its tactile paving system in response to user input and developments in accessible technology. This continuous progress highlights Singapore's commitment to establishing barrier-free environments that meet the requirements of many groups, including those who are visually impaired.

In conclusion, Singapore's LTA tactile pavement system is a prime example of well-thought-out urban accessibility infrastructure, enabling those with vision impairments to independently and safely traverse the city. LTA's tactile paving programs prioritize inclusivity and user-centered design, hence creating a more welcoming and accessible environment for all community members.

The Pattaya Redemptorist School for The Blind, Thailand

Figure 5. Classroom makeover for the blind of The Redemptorist School for the Blind, Pattaya, Thailand
Source: ArchDaily

The building of the Redemptorist School for The Blind in Pattaya, Thailand is built with a reinforced concrete structure with standard square rooms. The rooms were finished in plaster and paint. A classroom makeover for blind people transforms into a new multi-sensory cube decorated with vibrant materials and textures to replace the library.

The multi-sensory cube is a tactile and auditory learning tool that helps students develop their sensory skills and spatial awareness. By using different materials and textures on the surfaces of the cube, students can explore and distinguish various sensations through touch. This hands-on approach is crucial for visually impaired students as it helps them build a mental map of their surroundings and understand spatial relationships.

In addition to tactile elements, the multi-sensory cube also integrates auditory cues. These cues may include sounds that correspond to different surfaces or objects, enhancing the students' ability to associate specific sounds with textures or spatial concepts. This multisensory approach not only aids in learning but also makes the experience more enjoyable and stimulating for the students.

By leveraging multiple senses, the cube helps students overcome some of the challenges posed by their visual impairments, promoting greater independence and confidence in their daily lives.

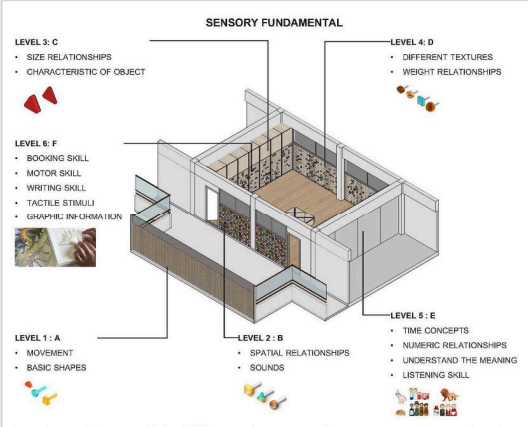

Figure 6. Sensory fudamentals in the classroom makeover for the blind of The Redemptorist School for the Blind, Pattaya, Thailand
Source: ArchDaily

Results and discussion

To create interior space designs that can bring the most benefits to all levels of visually imapired people, interview sessions have been conducted with MAB staff, Ms. Sumitha Ramasamy, Head of the Research and Development Department of the Malaysian Association for the Blind and her assistant and 5 visually impaired people. They are from all walks of life. They had been through all the inconvenient circumstances in their daily life. Some of them have been there and struggled due to their vision impairment.

The analysis of case studies and results from the interview sessions will be transcribed and discussed in this section based on different characteristics of visually impaired people's lived experiences.

Table 1. Demographics of the visually impaired interviewers

No	Gender	Age	Early / Late	Visual impairment
1	Male	24	Early	He had Squinting, had surgery at 7 years old, but the eyeball is back to normal after 17 years.
2	Male	24	Early	He was squinting and he was slightly colour blind. He highlighted that he couldn't differentiate the depth perception of an object and had surgery 2 years ago.
3	Male	25	Early	He had colour blindness with astigmatism.
4	Female	16	Late	Her right eyes where her right eye was diagnosed with Amblyopia (Lazy Eyes) around 9 years old. She stated that she could not differentiate the position of the things. If she doesn't use her left eye, the things she sees will be blurry.
5	Female	45	Early	She was totally blind when she was small and could not differentiate light from dark.

Most of the interviewees stated that the building design in Malaysia is not user-friendly for visually impaired people. However, the usage of braille tactile and texture has increased in recent years.

According to MAB staff, texture is the most important element for totally blind people. It helps them to differentiate the space with the sense of touch. These can be supported by the case study no.1. The interior wall at the School of Blind and Visually Impaired Children located in Gandhinagar, India was finished in different types of textures for the users to differentiate the space. All the interviewees agree that the texture is important to enhance the spatial perception of a space. As Interviewee 2 was slightly colour blind, he recommends mixing the texture with greater differentiation to make it easier to distinguish space areas. However, texture walls are not used for all visually impaired people. Some of them can differentiate the space with their visually impaired.

Therefore, some of the interviewees suggest to have a colour contrast on the texture too. Colour contrast lets the user easily distinguish the area and makes the space more visible. It also would help to make it more attractive and visually appealing. Besides that, colour contrast lets

people with colour blindness see better. According to case study No.1, it shows the application of colour contrast with the furniture in the surrounding space. This finding from case study No.1 is also supported by MAB staff, stating that colour contrast is the most important thing to be considered when an interior space is designed for all levels of people with visual impairment. The greater the colour contrast on the flooring, the better it is to help to clarify depths of the space, such as the walkway and the corner of the space.

In addition, a partition inside a space is important to help visually impaired people to enhance their spatial perception. And yet, the selection of the texture materials to be used for a partition needs to take precautions and be aware when using them. MAB staff stated that clear glass is prohibited from being placed as the partition. But, glass with texture such as tinted glass or glass block design with texture on top can be accepted. This situation was supported by interviewee 1. Despite using partitions to distinguish navigation, visually impaired people should remove fewer barriers in the interior space. According to MAB staff, the designer must be aware of things that appear on the forehead to avoid accidents.

Moreover, interviewee 3 facing astigmatism said that he would recommend the interior space reduce the usage of glass or reflective materials. A huge amount of usage of reflective materials in an interior space will make them feel overwhelmed when trying to navigate such spaces. This was agreed by all the interviewees, especially interviewees 2 and 4 who faced problems in determining the depth of an object. Interviewee 1 stated that too many of the translucent partition boards or clothes will make him confused too. Thus, matte surface materials were recommended to be used.

Apart form texture, lighting installation in an interior space is crucial in enhancing the visibility of the space. For individuals with partial vision, strategic and proper lighting create a better environment for them as a properly designed lighting helps in reducing glare and creating contrasts in areas such as walkways, stairs, and different areas. To further elaborate, well-designed lighting can better highlight textures and other tactile areas, further aiding those who rely on touch to navigate around. When the lighting of an interior space is carefully considered with the needs of visually impaired individuals in mind, designers can create environments that are not only more accessible and functional but also more comfortable and welcoming.

The interviewees stated that the interior design for the National Museum and the MRT station in Singapore gave them the best experiences in the guidance of space. They were satisfied and happy when they were there experiencing well-planned and designed for visually impaired people. In other words, as evidenced by case study No.2, the tactile paving system used by LTA Singapore is a success.

Besides texture, MAB staff recommends placing some voice-over sensors in an interior space. This would help different levels of visual impairment people as well as blind people to navigate correctly. As mentioned in the Literature Review, Cho, J.-D., the combination of multisensory helps the visually impaired, enhancing their spatial perception well.

To summarise, it is said that multiple sources of sensory inputs play an important role in helping visually impaired people who are really in need of guidance in their life. Texture in interior design serves as a great utility for visually impaired people in helping them to differentiate areas in an interior space. It is one of the important elements to provide a sense of touch and feel for all levels of visual impairment people to explore the world.

Instead of looking at textures that creates a sense of depth and dimension to make the environment more engaging and stimulating for visually impaired people. Further research on how lighting or colour contrasts can help or affect the visually impaired people could be conducted. Investigating the effects of different lighting conditions and color schemes in the application in spaces that are preferable by visually impaired people. Furthermore, gaining additional insights from other professionals such as ophthalmologists would help provide a clearer understanding of the specific needs of visually impaired individuals. These professionals can provide expert knowledge on how various eye conditions affect vision and offer recommendations on environmental adaptations that can aid navigation. Getting in touch with ophthalmologists can help create more customized design solutions that are effective in addressing the unique challenges of visually impaired people. This will help ensure that interior spaces are optimized for their safety, independence, and overall well-being.

Conclusions

As a result, it is believed that the texture can help to enhance spatial perception for visually impaired people. The combination of different materials with distinct textures will help enhance the spatial perception of visually impaired users. The greater the differentiation of the texture, the better the spatial perception created for the user. A further exploration of these topics can be achieved by combining textures with contrast colours. By combining textures with contrast colors, visually impaired individuals can experience improved navigability and spatial awareness. The texture provides tactile cues that help them differentiate between different surfaces and objects, while contrast colors enhance the visibility of these textures, making it easier for them to identify and navigate their surroundings. This combination can greatly enhance their independence and overall quality of life. Walking through a well-designed interior space for visually impaired people will build their self-confidence.

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Author(s) contribution

Ng Kay Kay contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Safial Aqbar Zakaria contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.