Visually Impaired People's Demand for Supermarket Public Environment and Optimal Design from the Perspective of Perceptual Behavior

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Shizhe Li, Zhenwei You*
School of Digital Media and Design Art, Beijing University of Posts and Telecommunications, Beijing, China
*Corresponding author, e-mail: ivoyou@qq.com

Abstract
Through the sequential action notation method, the visually impaired people's perception needs and behavioral characteristics of the supermarket environment are deeply explored, and the optimization of the barrier-free design of the supermarket public environment is provided. Use the sequential action notation method to grasp the personal experience pre-demands of the visually impaired individuals for public spaces, and by recording the behaviors of the visually impaired people in the shopping process of the supermarket, combined with semi-structured interviews, to conduct an in-depth analysis of their needs in the supermarket environment. Dig and analyze to find the design entry point. Visually impaired people appreciate coherent, predictable layouts and horizontal and vertical movements. The three major obstacles in supermarket shopping for visually impaired people are the obstacle of walking alone in the supermarket, the obstacle of obtaining information on the distribution of the supermarket area, and the obstacle of obtaining detailed information of goods. This design research uses multi-channel sensory and RFID technology to provide safe and autonomous purchasing services for visually impaired people.

Keywords
Visually impaired people; Perceived behavior; RFID; Sequential action notation

Introduction

China has the largest number of visually impaired people in the world. Data from the China Disabled Persons' Federation show that the number of people with visual disabilities in China was estimated to be 12.63 million at the end of 2010 based on the total population in the sixth national

population census and the second national sampling survey on disabled persons in the proportion of disabled persons in the total population of China and the proportion of all kinds of disabled persons in the total number of disabled persons in China. Due to the dual reasons that physiological factors and the status quo of barrier-free public environment design in China cannot meet the travel needs of visually impaired people, it is very difficult for visually impaired people to travel, which leads to a lot of experiences in their lives. Without help, the range of movement is usually limited to familiar areas. Visually impaired people are in urgent need of a public environment design code that can meet their use needs and help them to be as comfortable in the public environment as the sighted people.

China attaches great importance to the legal rights of the disabled people including visually impaired people. Caring for vulnerable groups and designing for visually impaired people has become an important humanistic trend. At present, the research results on the daily life of visually impaired people are lacking and the direction is scattered. The research and discussion directions mainly include the guide system, interaction design, display design, barrier-free access, walking AIDS software and equipment in cultural and educational places and landscape areas including museums and public libraries. However, the barrier-free design of supermarkets for visually impaired groups is still very limited. Yang Wenxin et al. believe that the strategies for visually impaired consumers to overcome the shopping obstacles in supermarkets are to establish special areas in supermarkets, add Braille signs on commodity packages, and introduce special shopping guides. Zhang Meng believed that the guidance system of the supermarket should include the guidance sign at the entrance, the overall plan guidance, the blind path continuous guidance, the information node diagram, the cross touch and the continuous information of the handrail.

Therefore, by studying the needs, perceptual characteristics and behavioral habits of visually impaired people, combined with supermarket design elements, etc., this paper provides guidance for the design of barrier-free supermarkets for visually impaired people, and strives to improve the supermarket shopping environment for visually impaired people, so that "visually impaired people go shopping alone in supermarkets" becomes possible from impossible.

Elements of Perceived Behavioral Needs of Visually Impaired People in the Public Environment of Supermarkets

Building a sense of space and location

Radio Frequency IDentification (RFID), is a new type of communication technology. Through Radio Frequency, the target is identified, read and written, and two-way data communication is completed without contact, so as to achieve the purpose of target IDentification and data exchange. It

is considered as one of the most promising information technologies in the 21st century . With the progress of social science and technology, the Internet of Things is developing increasingly under the requirements of high efficiency, and RFID technology will play a huge role in various industries, such as global positioning system, biometric technology, etc. Radio frequency identification technology has also been applied to many practical scenarios .

Visually impaired people perceive space through non-visual senses. Hearing, touch and smell can help them obtain information timely and efficiently.

Table 1 Classification of Guide Identifiers

Classification of Guiding Signs	Characteristic	Usage Scenarios
Hearing Sign	Voice prompts & Some specific sounds in the environment.[8]	Explicit language & The sound of barking, etc
Touching Sign	More figurative than auditory reception of information.	Braille & Blind road
Tasting and Smelling Sign	Limited usage scenarios. Not too many types of smell.	Flower shop, cake shop, etc.

The human dimension of information acquisition for visually impaired people

1)Walking scale

The static scale of the visually impaired is the same as that of the sighted, but it is different when walking. When visually impaired people walk on their own with a blind staff, they generally explore and march with a stride length of 20-25cm [9]. When carrying a guide dog, the dog usually moves forward close to the left side of the body of the visually impaired person, and the width of the front and side of the blind person is larger than that of the sighted person. In order not to affect the passage, more than 400mm space should be left on both sides of the blind path.

Table 2 Comparison of walking scales between sighted people and visually impaired people

Category	Front Width	Side Width	Height of Sighting Line	Rotate (or use aids) 180° Radius	Passable Vertical Height Difference
People of good sense	450mm	300mm	1600mm	Φ600	150-200mm
People with the blind staff	600-1000mm	700-900mm	-	Φ1500	150-200mm
People with a guide dog	800-1100mm	1100-1500mm	-	Φ1500	150-200mm

2)Touching scale

Normal people's fingertip threshold is 2.2-3.0 mm, while the visual impaired people's threshold is nearly half of the normal people's . At present, Braille is the most common tactile symbol for fingertip perception, and the convex height of text and text should be about 5mm. The range of touch of the hand is limited, so the range of motion of the arm needs to be taken into account. The upper arm reaches forward to form an Angle of 45 degrees with the ground, and the arm reaches 700cm above the ground as the appropriate touch range. The positions below 400mm and above 1300mm above the ground are dangerous areas for people with poor vision.

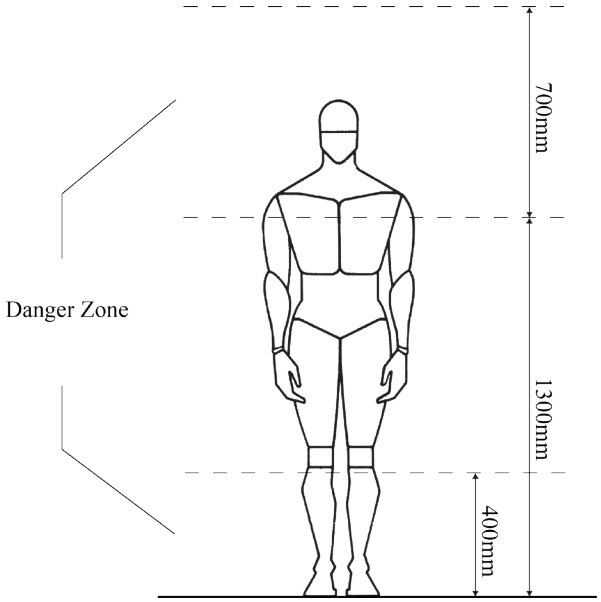


Figure 1 Visual impairment risk zone diagram

Methods

Subjects

The 5 subjects selected for this experiment were all visually impaired people with grade 1 blindness, aged from 27 to 40 years old, including 1 male and 4 females. Considering that the current environment in the supermarket could not be full of practical factors for the subjects to complete the shopping alone, the subjects required a friend or relative to accompany them to complete the experiment. In order to eliminate the interference of factors that the subjects were very familiar with the environment, the experimental environment was selected in Carrefour Dinghuiqiao store, which the subjects had not visited before the experiment.



Figure 2 Appearance 1



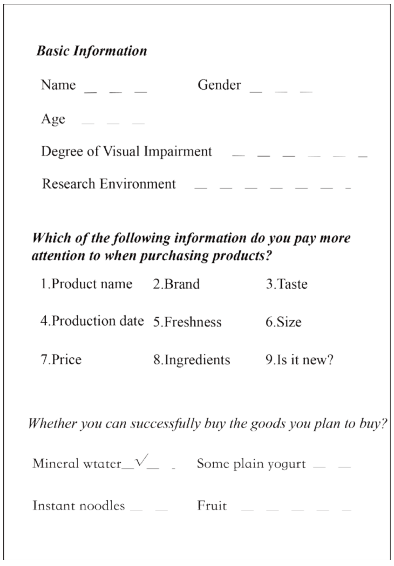
Figure 3 Appearance 2

Materials and Methods

The research method used in this experiment is sequential action notation. Through the continuous action composition of the subjects, psychological activities and various relevant elements of the surrounding environment, all these elements are continuously recorded in chronological order, and the characteristics of each element and the relationship between the elements are analyzed to determine the characteristics of the subjects' actions.

The materials included a survey paper and a Go Pro motion camera. There are two kinds of survey paper, which are used to record the basic information of the subjects and the information obtained during the interview. Due to the large area of the experimental site, it was not possible to set a fixed observation camera position in advance, so we chose to carry a compact Go Pro to follow the whole process to avoid attracting attention and bringing psychological pressure to the subjects.

Figure 4 Test paper style 1



Basic Information

Name _ _ _ Gender _ _ _

Age _ _ _

Degree of Visual Impairment _ _ _ _ _ _

Research Environment _ _ _ _ _ _ _

Which of the following information do you pay more attention to when purchasing products?

1.Product name 2.Brand 3.Taste

4.Production date 5.Freshness 6.Size

7.Price 8.Ingredients 9.Is it new?

Whether you can successfully buy the goods you plan to buy?

Mineral wtater_✓_ _ Some plain yogurt _ _

Instant noodles _ _ Fruit _ _ _ _ _

No.	Question	Answer
1	Is it your first time to this supermarket?	
2	How did you feel when you first entered vthe supermarket?	
3	Do you feel insecure about walking with your shopping cart?	
4	Why did you put down these two bottles of water?	
5	What are the selection criteria?	
6	Why do you repeatedly touch the water bottle outline?	
7	why do you lift your fingers out?	
8	Can you hear more than one radio in the fruit and vegetable sales area?	
9	What do you think when you can't find staff?	
10	What do you rely on to choose small kumquats?	
11	Are you clear about the layout in the company of friends?	
12	How do you feel about the supermarket after shopping?	

Figure 5 Test paper style 2

Figure 6 Shooting effect of Go Pro motion camera

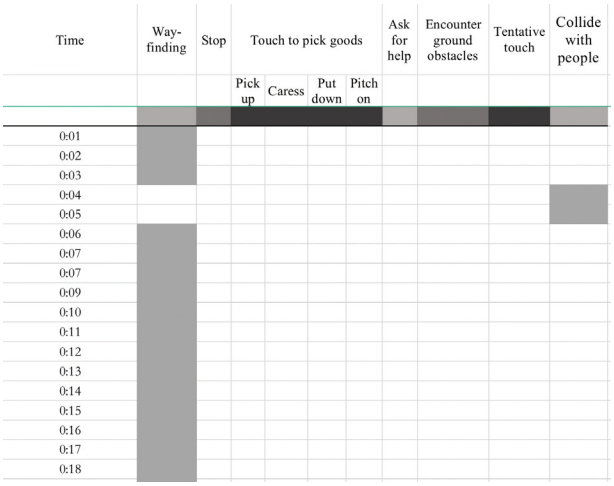


Research Program

Get in touch with the subject ahead of time and plan your purchases. According to the information, prepare a prompt: "From now on, we will conduct an experiment to observe the shopping behavior of visually impaired people in supermarkets. You come to the supermarket to buy mineral water, yogurt, instant noodles, fruits and other goods. From now on, do your shopping as usual. Any other questions? So, let's start the experiment." And this paragraph of words before the beginning of the experiment to listen to the subject, through the instruction to the subject to do the task action expressed. After the subjects confirmed the clear instructions, they could start the experiment, and the Go Pro motion camera was used to record the behavior of the subjects throughout the whole process.

Adobe Premiere was used to edit the observation and recording video. Considering the particularity of the subjects, head and eye movements were not considered in the analysis. According to the ac-

tions and hand movements of the subjects recorded in the video images, the contents of the analysis were sorted into different elements: finding the way, stopping, choosing goods by touch, encountering obstacles on the ground, trying to touch, seeking help, and colliding with others. And make Frame by Frame analysis table (Frame by Frame analysis table) on Excel according to each action element. Considering the long duration of video, the minimum time unit is adjusted from "frame" to "second". Analyze the actions of the subjects and related environmental changes, fill the cell sequence, analyze the filled table, and grasp the division and change points of the actions.



interview process

Considering that the current epidemic has not completely ended and it is inconvenient for visually impaired people to travel, the interview method is determined to be one-on-one interview online. Both the interviewer and the interviewee are required to be in a quiet environment to ensure the recording effect.

This interview was conducted in a semi-structured interview, with interactive interviews about the actions in the experiment. It is necessary to clarify the questions and methods before the interview, and also leave more room for the respondents to express their own ideas and opinions, so as to obtain all the information of the subjects in the experiment. During the interview, the subjects were asked questions while describing the recorded video content, and asked to match their own memories with the action video. During the interview, a recording device was used to record the conversation process with the subjects, so that the content of the interview could be analyzed later.

Discussion and Conclusion

By analyzing the experiment data and interview after the information obtained, by those in the supermarket, can be divided into three stages: stage 1 looking for want to buy goods of kinds of shelves, stage 2 pathfinding walk to the aisle looking for target goods, phase 3 after the shelves with the hand to the export goods before carefully identify business types and ask the staff. Thus, three major obstacles for visually impaired people in supermarket shopping can be summarized as follows:

① Obstacles to walking alone in the supermarket
② Obstacles in obtaining regional distribution information of supermarkets
③ Access to detailed information.

Design Scheme

Design Objectives

The design scheme should ensure the safety of the visually impaired. In the construction of supermarket facilities, the accuracy of information prompts and the safety of used materials should be ensured. For example, the shape of facilities to avoid the design of edges and corners, the ground to do anti-slip treatment, the display of goods to avoid falling to hurt customers and cause economic losses.

The design scheme should ensure that visually impaired people can shop smoothly. In terms of information needs, the barrier-free supermarket should meet the navigation and positioning needs, commodity information acquisition needs and voice prompt needs of the visually impaired, including the user's location and commodity area, so that the visually impaired can go anywhere they want in the barrier-free supermarket.

The design scheme should pay attention to the emotional needs of the visually impaired. In addition to ensuring that visually impaired people can normally complete the shopping process, it is also necessary to pay attention to the emotional needs of visually impaired people. By purchasing goods in barrier-free supermarkets, users can operate conveniently and efficiently, improve user experience, and play a positive role in helping visually impaired people integrate into society.

Realization of walking alone in the supermarket -- Design of auxiliary positioning bracelet

The navigation AIDS in the form of bracelets are combined with RFID technology. The active elec-

tronic tag in the blind brick of the supermarket can be triggered by the hand ring, and the bracelet can vibrate and give voice prompt according to the program setting. Visually impaired users are required to turn on the power and adjust the volume and speed to adapt themselves. A simple tutorial should be broadcast after the bracelet is activated, so that visually impaired users can learn how to operate it through the introduction, helping them to use it more comfortably. The band of the bracelet is made of silicone material, soft and safe, with high cost performance. The three buttons on the surface of the bracelet are the power button, the slow button and the speed button. The power button is sunken down, while the other two speed-adjusting keys are raised and have arrowhead-shaped textures for visually impaired people to identify. On the side are the charging port, the playing port and the volume adjustment knob.

Figure 8 Detail effect of the bracelet Figure 1

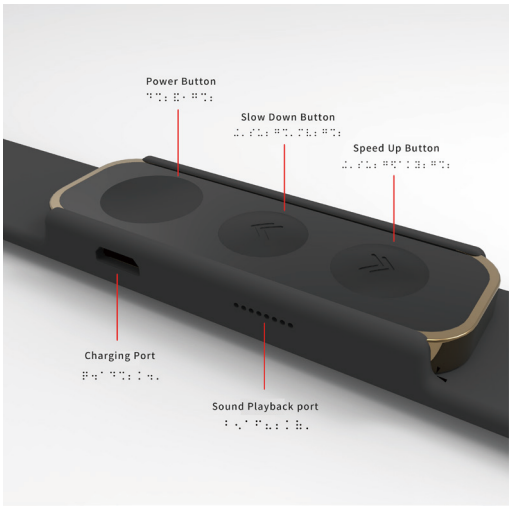


Figure 9 Detail effect of the bracelet Figure 2



Figure 10 Effect Figure 1

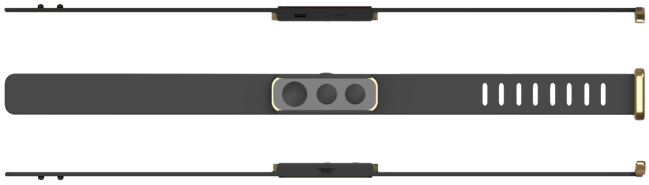


Figure 11 Effect Figure 2



Acquisition of supermarket regional distribution information -- supermarket streamline and layout design

Visually impaired people prefer coherent and predictable layout and horizontal and vertical moving lines. At the same time, considering that visually impaired people have a larger scale of movement than those with clear vision, the width of the channel should be widened accordingly.

1)Blind lane setting

Blind passage is widely used in many countries to help visually impaired people get out of their homes and live socially. In this study, the size of the blind channel brick was determined as 250mm. In many developed countries, blind passage is an effective way to guide the blind. And the length and density of blind road is one of the indicators of civilized city selection. In the supermarket, the ground should be laid continuous blind road, together with RFID technology and bracelets for visually impaired people to navigate, to ensure that they can walk safely and freely in the supermarket.

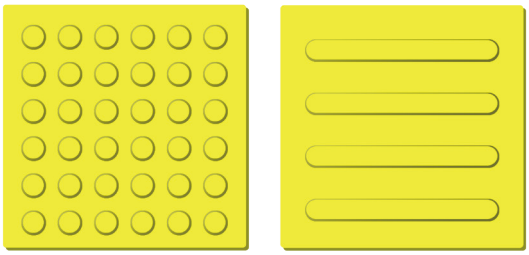


Figure 12 Brick diagram of blind channel



Figure 13 Layout of the supermarket

2)Shopping flow and layout design

The layout of the barrier-free supermarket is shown in Figure 13. The whole supermarket is rectangular, and the entrance and exit are on the same side, followed by the cashier area. Next, the large area extending inward is the sales area. The sales area is subdivided into 5 areas, which are respectively the department store daily chemical area, the dry food area, the beverage and beverage area, the fruit and vegetable cooked food area and the refrigerated and frozen area. Each of these five areas has an independent space enclosed by a high wall, and there is a passageway between each of the two areas for quick passage through the front of the receiving area. Each small vending area has an entrance and an exit at each end leading to two main channels at the edge, avoiding the flow of people. The service area is located in the inner part of the supermarket, with toilet, rest area, service desk, etc. Visually impaired people can directly reach the service area without detour on the main channel.

Due to different needs of customers, shopping methods can be divided into three types: a. Purposeful purchase of goods, corresponding to the pink route in the figure; B. Shopping while shopping, which corresponds to the yellow route ② in the figure; C) The shopping process is interrupted (to

take a break or go to the bathroom, etc.), in the figure corresponding to the blue route ③ .

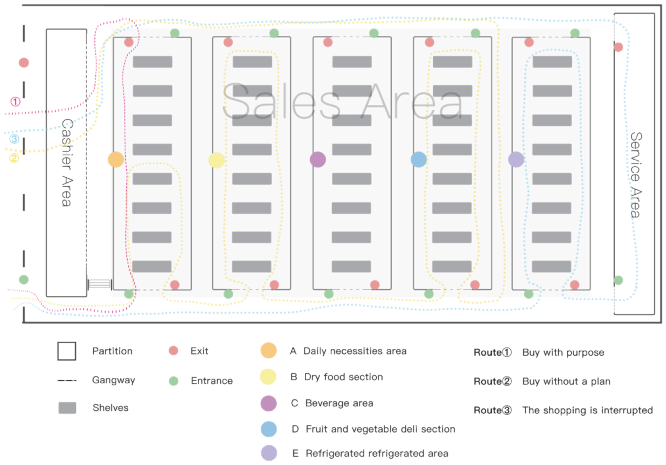


Figure 14 Flow diagram of supermarket

Commodity detailed information acquisition - shelf optimization design

Shelves are the most numerous and important facilities in supermarkets. Their functional design determines the way users take goods, and also greatly affects the satisfaction of visually impaired people when shopping. Visually impaired people can complete the pathfinding and the determination of the general division of commodities independently with the assistance of the bracelet and RFID technology, but the further detailed information identification of commodities still cannot be completed. On this premise, the commodity shelves, which are highly related to the supermarket environment, will be optimized to meet the needs of visually impaired people.

The shelf is provided with a control panel, including a plurality of mechanical buttons and an electronic display screen, the control panel is provided with a prompt sound play port. The buttons include the "Previous" button, "Next" button, Arabic numerals 1-9 button, "Put back" button and "Confirm" button, all of which are raised and equipped with Braille. The gap on the right side is for taking and putting goods. Considering the size of people, it is 1m above the ground. The color of the shelf is orange, bright and eye-catching, and strong penetration, which plays a role of reminding and warning to some visually impaired people.

Visually impaired users can change products through the "Previous" and "Next" buttons, and the column of the selected current product will be lit up to alert users with residual vision. If customers are interested, they can scan the two-dimensional code of product information displayed on the electronic display below and press the "confirm" button. Then the voice broadcast will prompt the user to choose the purchase quantity. The user can press the corresponding number button and press the "confirm" button. If the user does not want to buy the product and wants to put it back, place the

product in the pick and release port, press the "Put back" button, and then press the "confirm" button.

Figure 15 Shelf size diagram

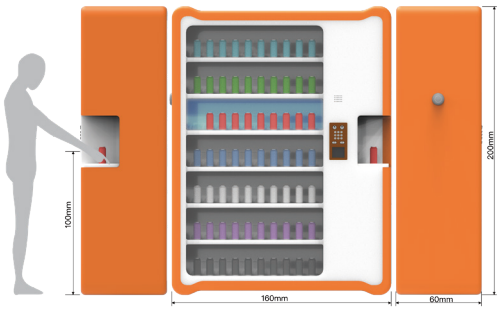


Figure 16 Detail drawing of shelf operation panel

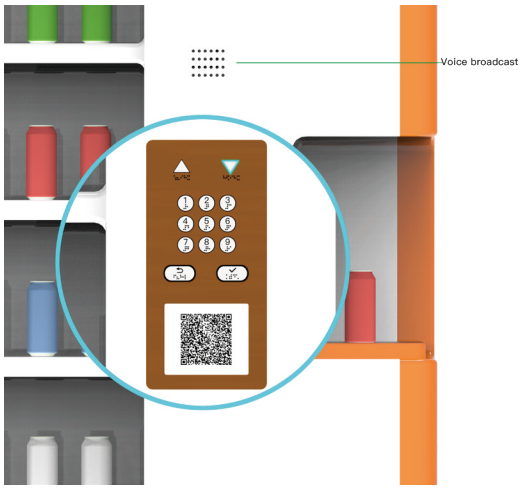


Figure 17 A rendering of the shelf



Conclusion

To explore the practical needs of visually impaired people in the supermarket shopping process based on the method of combining sequential action notation and visual impaired people's perception and behavior. Optimize the barrier-free design scheme of the existing supermarket public environment. With the development of social civilization, the tolerance degree of the society to the

vulnerable groups is deepening, and the design of barrier-free environment is also constantly putting forward new requirements. This study theoretically provides a new perspective for the field of barrier-free design for visually impaired people, and provides a certain reference value for designers to design public environments for visually impaired people. However, this design achievement is still in the conceptual design stage, and the limitation lies in the lack of feasibility test analysis of the actual use process, which needs to be further tested to be scientific.

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