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A Study of Blind People based on Morphological Recognition Color - Graphic Research

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Objective: This paper puts forward a way that is most helpful to blind people's touch and reading of graphic color, and improves the situation that the blind people can't see the color in the daily life of "seeing" art exhibition, which increases the field of color in the blind people's lives and helps the blind people to study art creation in the future. ① Understand the infinite charm brought by color and improve self-worth ② Broaden the employment scope of the blind ③ Benificial to enrich the spiritual and cultural life of the visually impaired, provides an effective demonstration for the blind to quickly read the application field of graphic color, which is the basis for the future study of dynamic graphic color.

Background: Blind people have problems such as "travel difficulty", "image recognition difficulty", "color recognition difficulty" in their lives (Meng et al., 2017). They cannot appreciate the color elements in paintings and use complex colors for artistic creation. They can only rely on the sense of touch, hearing and smell for sensory compensation because of the visual impairment. When they face such information as colorful graphics and images, there is always a lack of effective information acquisition methods. The traditional method is to obtain the rough shape or the voice description image through the tactile image; the blind volunteers also play a vital role in helping the blind to understand the analysis and describe it to the other party through the form of voice; secondly, the blind electronic assistant device can scan and understand its image and color through advanced recognition technology, then describe it in the form of voice (Huiying et al., 2014). However, the artificial description of color can not exclude the understanding of certain human consciousness and it can not convey color or graphic information without damage as well; the electronic assistant device for the blind is too modular and lack of imagination; most importantly, color images replace in a high speed in the Internet era, artificial help and paper tactile images can not carry tactile color or image information in real-time.

Method: Firstly, the basic problem is understood through the user interview method. Secondly, the existing blind people's method of touching and reading color is used to determine the problem. Through the observation of the blind people's daily study life, the range of graphics that the blind people often touche is determined. Finally, the touch pattern is determined by the touch test.

Results: Through the extraction of blind people's daily learning and life of the commonly used graphics for induction. Secondly, setting the size and arrange the figure according to the Braille international standard and make a 3D model according to the set size and arrangement. Finally, according to the experimental model, we can test it in the specific population of the blind and get the figure that can make the blind touch and read quickly.

Conclusion: The choice, size, and arrangement of graphics are the key factors for blind people to read and touch graphics. It is the result of different tests.

Application: Focusing on blind users, the use of graphic shapes instead of color can be applied to blind exhibitions, blind teaching, blind art creation, blind film, blind social sharing, etc. We hope to help blind people open up new areas of reading through future research projects.

Keywords: Blind, Braille international standard, Graphic shape analysis, Graphic size analysis

1. Introduction

This project research is aimed at blind people's existing methods of reading. It can't make the blind people effectively and quickly read complex graphic colors and clarify the specific meanings expressed by the figures. According to the classification of visual obstacles, it mainly serves the problem of blind people's low color recognition rate. From the blind people's demand for color, through field investigation and analysis of blind people's perception of color and problems encountered in using traditional color recognition methods to propose a way for blind people to read complex graphic colors. By making models of different combinations and sizes, and testing in various environments of blind people's life, the pros and cons of the experimental data are compared and analyzed, and the figure shapes and figure sizes that blind people can quickly touch and read are obtained. It provides an effective demonstration for the application of the blind people's reading of graphic color. According to the latest data from the World Health Organization's official website in 2017, the number of people with visual impairment worldwide is 253 million, including 36 million patients with complete blindness, 217 million with moderate to severe visual impairment, and 81% of blind patients or moderate to severe visual impairment are aged 50 years or above. In August 2017, (Metadata analysis in the UK, 2017) a meta-analysis in the UK showed that between 1980 and 2015, about 36 million of the world's 7.033 billion people were blind (48% of the population had a crude prevalence, 56% of the population were women), 216.6 million had moderate to severe visual impairment (55% of the population were women), and 189 million had mild visual impairment (54% of the population were women). This data is still changing over time.

2. Research Status

Worldwide, there are many pieces of research on the related fields of the blind recognition image and graphics; but there are few pieces of research on the color field of the blind recognition image. The main types are: collecting light wave through the camera, converting light wave into sound, directly linking to the bone, and using the difference of sound frequency to "listen to color" (Harbison, 2012). Research on the environmental recognition of the visually impaired; through the high-speed camera, the world around the user is photographed, then the image is mapped onto a pair of OLED screens, and the visually impaired person can see the surrounding environment (Conrad, 2006). By designing a new type of tactile image generation structure, the new driver and the contact 1:n, a driving device sequentially drives a multiple of contacts and appropriately slows down the image refreshing speed without significantly affecting the touch experience (Yang et al., 2016). The tactile display system, which automatically collects image information and converts the image contour into vibration tactile stimulation is put on the back to perceive the figure (Juan et al., 2011). Based on the world's leading VSLAM technology, the intelligent device "eyes", enabling smart devices to fully understand the geometric features of the scene and reconstruct the environmental layout research with high precision (Yupeng, 2016).

The related researches of recognizing image color by touching image are as follows: ① the tight and alienated degree of micro fabric lines attached to cardboard helps blind people to recognize color, and at the same time, sequins, beads, and other small ornaments are added to the recognition system, so that users can recognize different color cardboard more easily (Santos, 2007). ② Use the "hue ring" to arrange the dots, which represent ten colors from red to purple. The basic colors are represented by bumps. The color of the clothes is perforated in the range of the hue ring (Sagawa et al., 2014). ③ On the paper of the specified size, the dots, and the lines are combined into different shapes to replace the color, and the special manufacturing process is used to make the concave and convex feeling, so that the blind person can touch to recognize the graphic color (Junyu et al., 2015).

2.1 Discover problems

In the actual investigation and interview, it is found that, (Figure 1), the concept of color is different for blind people of different levels; especially for those who are born completely blind, there is no concept of color in the mind of who is born blind; in general, people think that the world seen and perceived by born totally blind people is black. In fact, it is not black. It is empty and colorless; through the explanation, the blind people know what red means, what does blue mean, etc. They just know the meaning of the color, but accurately, they don't know what color is. If the blind people can feel black, it proves that the blind person is still sensitive, not blind.

Figure 1. Data collection and on-site interviews

Trying to use existing method of reading color to paint (Figure 2), for the convenience of research, we replace Taiwan's method with A and Japan's method with B. Since the Philippines' method is more complicated, there are changes of material, it is not conducive to the performance of the complex colors of paintings, so they are excluded.

Figure 2. Comparison diagram of existing touch reading color method and painting works

Among them, one square in group A represents one color, and 11 squares represent 11 colors; a whole cloth in group B represents one color, which is composed of different colors through the change of black dots; according to the existing way of touch reading color, try to make the existing graphics instead of colors to represent the painting content. As shown in Figure 3.

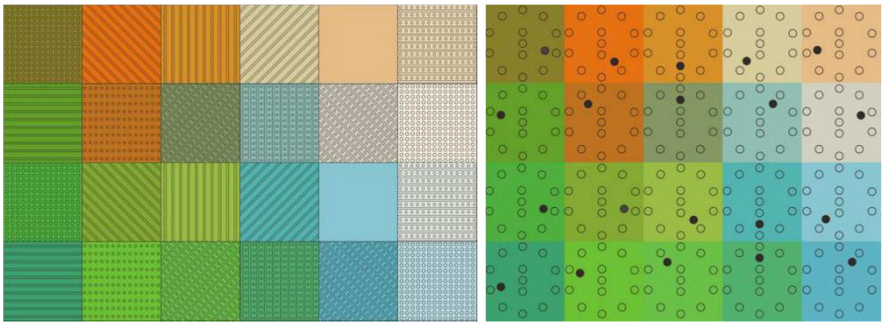


Figure 3. Existing painting works displayed in the way of touch reading color

By observing Figure 3, it is found that whether it is A or B, the way of replacing the color cannot avoid the limitation of the area, and the area is far larger than the area of most of the color blocks in the painting, so that the pixels of the picture are very low, and the painting has been lost. The meaning of the expression, such a pixel has completely separated from the painting. Therefore, neither a nor B can be used to express paintings, convey the meaning of paintings and the charm of colors.

We have made a comparison analysis of existing way of touch reading the colors of graphs. As shown in Figure 4.

The pain points of existing color recognition patterns for blind people

Region	Name	Character& time	Instructions	Diagram	Component	Generality	Express color image	Switch graphics	Common pain points / problems to be solved
Philippines	Color recognition of micro fabric line connection difference	Abad Santos (2006)	It is proposed to help blind people recognize color by the tightness and separation of micro fabric lines attached to the cardboard. At the same time, sequins, beads and other small accessories are added to the recognition system to make it easier for users to identify cardboard of different colors.		Specific materials, lines, density	Point, line	X	X	1. Unable to express complex color images (including painting works); 2. Unable to switch graphics and colors at will
Japan	"Hue ring" arranging dots	Sagawa Ken et al (2014)	Use the "hue ring" to arrange the dots, representing ten colors from red to purple. The basic colors are represented by bumps, and the colors of the clothes are represented by perforations in the range of the hue rings.		Dotted, raised, perforated dots		X	X	
Taiwan	Tactile color communication system	Lin Junyu et al (2015)	The whole system hue is defined by lines and points and their directions. The brightness is divided by the size of the point and the thickness of the line; the '⊙' symbol is positioned on the color card. This symbol must be within the range of the touch image. In the upper left corner, ensure that the visually impaired can correctly distinguish images when using this system.		Point, line, point line combination		X	X	

Figure 4. Common problem existing in the touch reading of the colors of graphs

According to the above analysis, there are common problems in blind people's identification of graphic color patterns: first, unable to express complex color images (including painting works); second, unable to switch graphics and colors at will; in view of this problem, we carry on the research and the experiment to finally draw the conclusion.

3. Research Process

3.1 User positioning

Based on the analysis results of user independent data, the user positioning mainly focuses on four aspects: blinding time, disability level, Braille cognitive level and work life background.

First of all, according to the time division of blindness, blind people are divided into congenital blindness and acquired blindness; through reading materials and on-site interviews, the born congenital blind people are called congenital blindness, who have never been stimulated by color, do not know what color is, and have no concept of color, among which the people without light sense are the most prominent. Acquired blindness is caused by other factors. This kind of people has been stimulated by color before and know what color is and what color represents. But with the extension of time, this kind of people will gradually forget what color is.

Taking the disability level of visual impairment as an example, this study adopts the grading table of blindness and low vision standards recommended by the World Health Organization (WHO) Geneva conference (WHO, 1973), as shown in Table 1. The grading of blind people and low vision disability is conducive to providing each blind person with relevant services suitable for their own touch reading.

Table 1. Classification of blindness and low vision

World Health Organization (who) standards for blindness and low vision in 1973		
Visual disability level		Best corrected vision
Low vision	1	< 0.3~0.1
	2	< 0.1~0.05 (2.5 meter index)
Blind	3	< 0.5~0.02 (1.0 meter index); Or visual field radius < 10 degrees
	4	< 0.02 ~ light sense; or visual field radius < 5 degrees
	5	No light sense

According to WHO-1973 standard, there are five levels of blindness. Blind people without light sense can't perceive color. Their world has no color, even black. Explaination does not work for blind people without light sense. We can only explain what color represents. ; < 0.02 ~ light sense is divided into the fourth level of blind people. This kind of people can only perceive black. Due to the single color, there is no other color contrast stimulation, so it is difficult to understand the meaning of black. Volunteers are also required to explain it. ; < 0.05 ~ 0.02 (1.0m index) is divided into the third level of blind people. These people can only perceive black and white. With the contrast stimulation of two colors, they can feel part of the meaning of color. The meaning of other colors needs volunteers to explain. ; < 0.1 ~ 0.05 (2.5m index) is divided into the second level of low vision. This kind of people can only perceive a certain number of fuzzy colors. The meaning of specific and detailed colors also needs to be supplemented by volunteers. ; < 0.3 ~ 0.1 is classified as the first level of low vision. This kind of people can perceive fuzzy color. The meaning of specific color needs to be supplemented by volunteers. Under the premise of a healthy body, these five kinds of blind people can create colorful works of art using touch and hearing assistance. What they need is a way to touch and communicate colors.

Thirdly, according to the classification of Braille cognitive level, each blind person has a different cognitive level and reading speed; the complexity of English braille is divided into three levels. Level 1 Braille refers to the possible arrangement of each point in a unit that represents only one letter, number, punctuation or special Braille component symbol - this is a one-to-one conversion. In Braille for this grade, a single cell cannot represent a word or abbreviation. The second level Braille replaces the first level Braille to save space. In the second level Braille, cells can represent abbreviations of words. Many cell combinations have been created to represent common words. Level 3 braille is the last level of Braille, which is basically the Braille shorthand system. It is not used in publications because it has not been standardized. It contains more than 300 abbreviations of words and makes full use of vowel ellipsis. Besides, to shorten the length of the final document, the spacing between words and paragraphs is reduced. Sometimes punctuation is used instead of words.

Fourth, according to the background of work and life, the work of the blind can be divided into masseuses, attorneys, psychological counselors, TCM, translators, tellers, plucked musical instruments (musicians), writers, lawyers, and telephone operators. Among them, massage, Braille translation, and writers will often use fingers and palms. After a long time of exercise, the sensitivity of fingers and palms will be greatly improved, so as to improve the speed of touch reading.

3.2 List one of the categories of disability for the blind

According to the user positioning, acquired blindness, < 0.05 ~ 0.02 (1.0m index) is the third level of blind people, Braille level II, and the massage profession is analyzed in detail. These kinds of people have color memory, accumulate more experience of touch reading in learning Braille and work, can quickly touch and read objects, understand the shape and size of objects, which provides a favorable premise for the later study of blind touch reading graphics.

3.3 How to replace color: replacing color with graphics

The Blair Braille system is a six-point square (Louis, 1824), vertical rectangle. With a set of letters arranged in different ways and regularly followed, and blank space, there are 64 changes to represent the text (Figure 5).

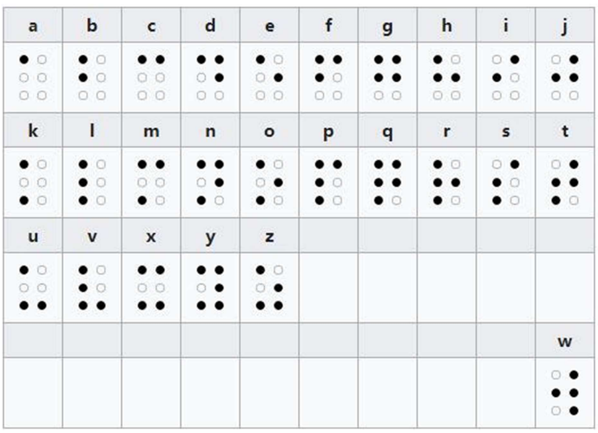


Figure 5. Schematic diagram of Blair Braille system

Figures are the most frequently contacted by the blind in life and learning; From another point of view, flattening Braille and connecting blind spots will also form some irregular figures (Figure 6).

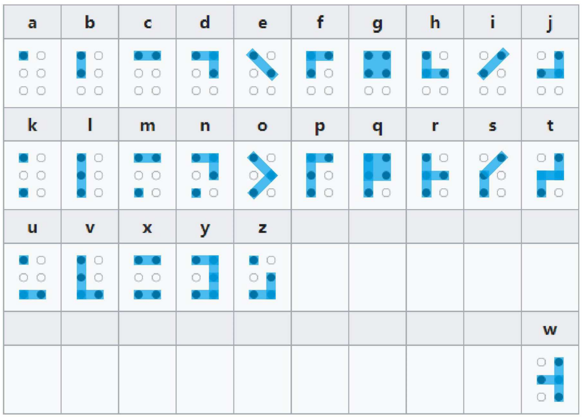


Figure 6. Connect Blair Braille to a graphic

After zooming in on the paintings, film and television works and images, you will find that all the images are composed of small pixel squares (Figure 7). These small squares have a clear location and assigned color values. The color and location of the small squares determine the appearance of the image. In essence, it also shows that the image is composed of small pixel squares. The size and precision of each image are determined by the number of small pixel blocks.

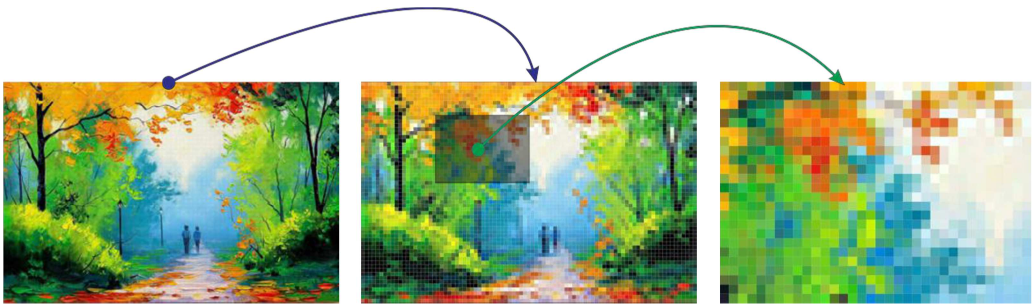


Figure 7. Analysis of pixel diagrams of paintings

3.4 Graphic shape reasoning

Since the scope of life of the blind is relatively small, so the shape of the figure is summarized from two aspects of the blind: first, from the common figure that touched by the visually impaired people in daily life; second, from the common figure that touched by the visually impaired people in their learning life. In daily life, the blind will be familiar with all kinds of graphics from various auxiliary information. This is a potential way of learning. Classification is subconsciously done in the mind, from which to get different shapes of graphics. In learning and living, most of the knowledge of Braille, graphics (Susan, 2013), mathematics and so on are acquired in schools for the blind, and the teaching aids for the blind are important ways to acquire graphics; some special graphics will also be learned in other ways, such as the blind painting exhibition, etc. We have summed up the commonly used graphics in learning and living (Figure 8).

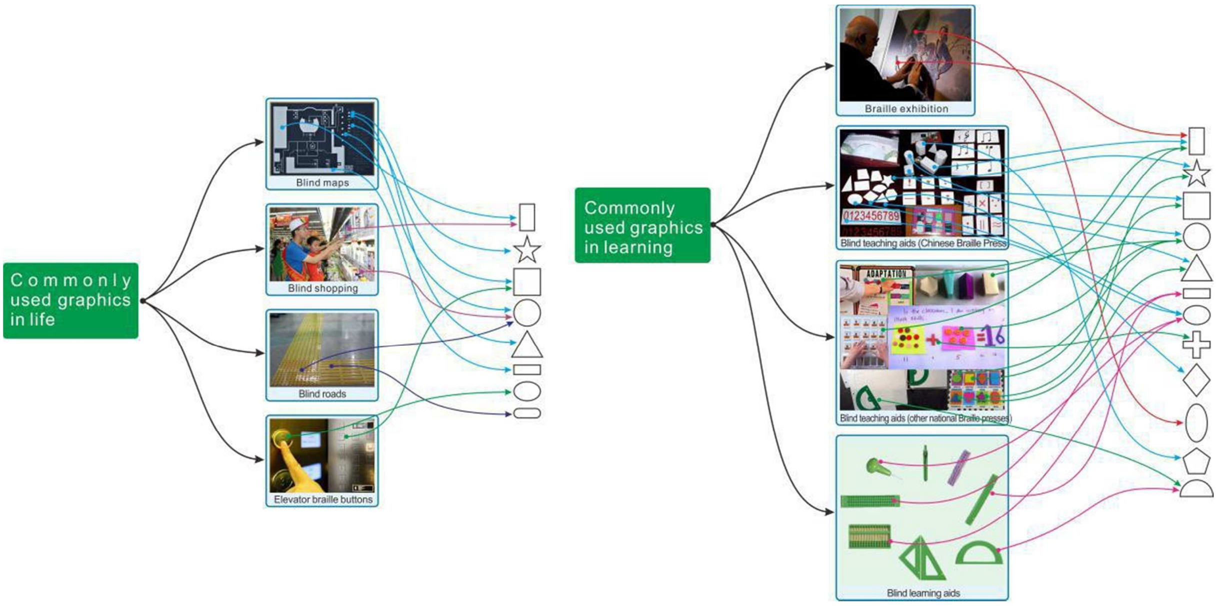


Figure 8. Schematic diagram of the shape

Through the above reasoning research, the commonness of the graphics used in various scenes is extracted to guide the induction of graphics. Excluding the similar lines, 11 figures were extracted as the test objects, which are: regular circle, star, square, semicircle, horizontal rectangle, diamond, pentagon, regular triangle, vertical rectangle, cross shape and ellipse. These 11 graphs are the first stage of the graph instead of the color test. The final graph can only be determined after the test according to the specific data analysis. As shown in Figure 9.

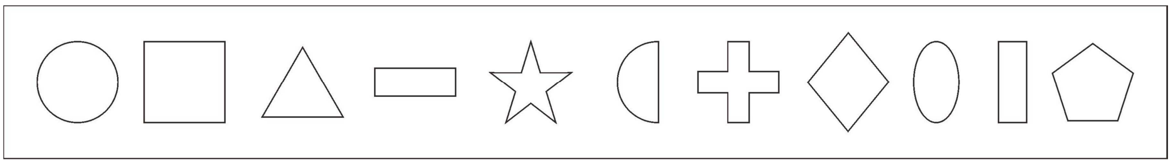


Figure 9. 11 figures concluded

4. Experiment

This study conducted an experiment to find the size and layout size of the graphics and replacement color graphics that are most suitable for blind people to use.

4.1 Graphic layout form

4.1.1 Graphic layout size

The arrangement of blind spots in Braille is strictly defined (GB/T 15720-2008, 2008), which is divided into point diameter, point height, point distance, square distance, line spacing, etc.; the change of these parameters will change the reading speed of blind people and the habits of blind people. In order to make the blinds read faster, they should follow their reading habits, so we set the size by referring to the dot pitch in the Braille international standard when laying out the dimensions. For the sake of easy understanding, the meanings of the square distance, the point pitch and the point diameter are illustrated in detail in Figure 10.

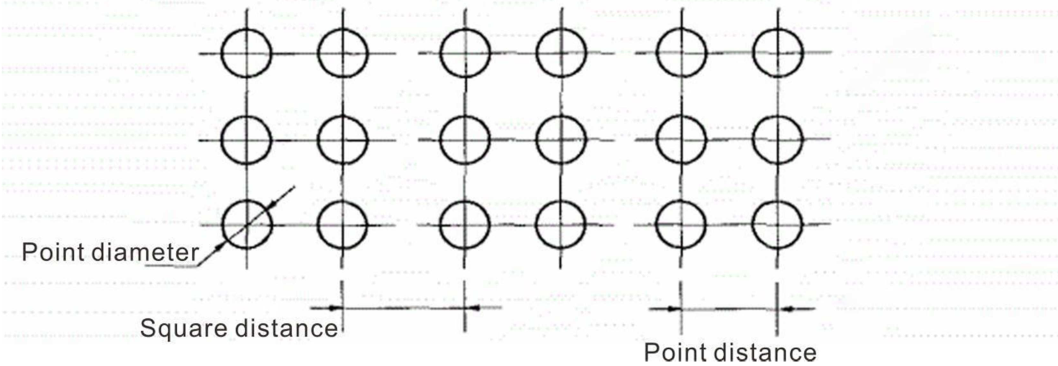


Figure 10. Schematic diagram of point distance and square distance of Braille international

According to "Braille Cell Dimensions", Tiresias - Scientific and Technological Reports, "Braille on folding Cartons", European Carton Makers Association, Sept 2005, European Standard Developments - CEN. Standard EN 15823 and PharmaBraille Braille font system announcement, Braille requirements in the United States, France, Germany, the United Kingdom, Italy and other countries (SteelDesign, 2009), As shown in Figure 11.

	HORIZ DOT TO DOT MM	VERTICAL DOT TO DOT MM	CELL TO CELL MM	LINE TO LINE MM	DOT BASE DIAM MM	DOT HEIGHT MM
American Library of Congress	2.5	2.5	6.25	10.0		0.5
American National Library for the Blind	2.28	2.28	6.09	10.16		0.5
American Standard Sign	2.3 – 2.5	2.3 – 2.5	6.1 – 7.6	10.0 – 10.1	1.5 – 1.6	0.6 – 0.9
Australia Sign	2.29 – 2.50	2.29 – 2.54	6.00 – 6.10	10.16 – 10.41	1.40 – 1.50	0.46 – 0.53
Californian Sign	2.54	2.54	5.08			0.64
ECMA Euro Braille	2.5	2.5	6.0	10.0	1.3	0.5
Electronic Braille	2.4	2.4	6.4			0.8
English Interline (alternate print and braille lines)	2.29	2.54	6.00	12.70	1.4 – 1.5	0.46
English Interpoint (braille on both sides of the paper)	2.29	2.54	6.00	10.41	1.4 – 1.5	0.46
English Giant Dot	3.25	3.25	9.78	17.02	1.9	0.81
Enlarged American	2.54	2.54	7.24	12.70		
Enhanced Line Spacing	2.29	2.29	6.1	15.24		
French	2.5 – 2.6	2.5 – 2.6		>10	1.2	0.8 – 1.0
German	2.5	2.5	6.0	10.0	1.3 – 1.6	⩾0.5
International Building Standard	2.5	2.5	6.1 – 7.6	10.0 – 10.1	1.5 – 1.6	0.6 – 0.9
Italian	2.2 – 2.5	2.2 – 2.5			1.0	0.5
Japanese	2.13	2.37	5.4	13.91	1.43	0.5
Jumbo American	2.92	2.92	8.76	12.70	1.7	0.53
Korean	2.0	2.0	5.0	6.0	1.5	0.6
Latvian	2.5	2.5	5	10.0	1.6	0.45
Marburg Medium	2.5	2.5	6.0	10.0	1.3 – 1.6	
Marburg Large	2.7	2.7	6.6	10.8	1.5 – 1.8	
Portuguese	2.29	2.54	6.0	10.41	1.4	
Small English	2.03	2.03	5.38	8.46	1.4 – 1.5	0.33
Spanish	2.5	2.5	6.0	10.0	1.2	
Standard American	2.34	2.34	6.22	10.16	1.45	0.48
Swedish	2.5	2.5	6.0	10	1	0.25

Figure 11. Braille standards in different countries around the world

In order to clarify the national standards for Braille in different countries of the world, the data are summarized according to the above figures, as shown in Figure 12.

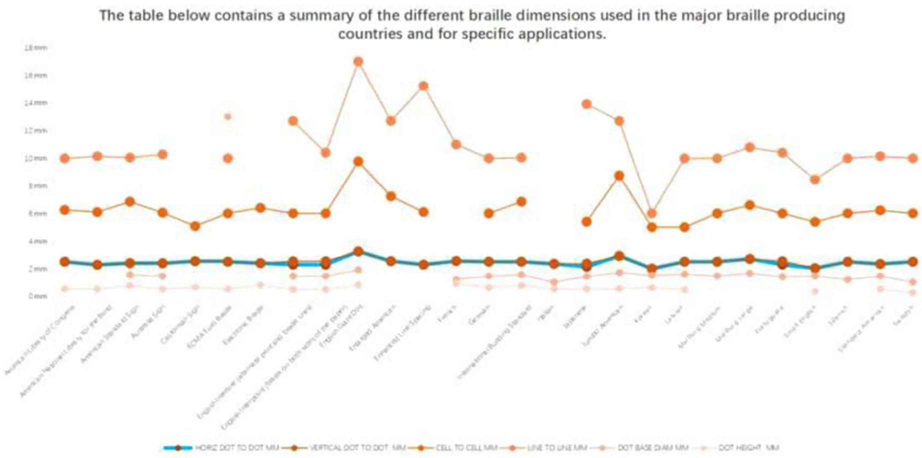


Figure 12. Chart summarizing Braille standards for different countries around the world

Figure 12 clearly shows that the Braille point pitch in different national Braille standards is 2.03~2.92mm, which also includes the national Braille standard of China, which is 2.2~2.8mm; the resolution combined with finger tactile sensor is about 2.5mm, namely 10ppi (pixel per inch), which is far lower than the visual resolution. Therefore, the dimension of the Braille international standard is used for testing. Based on the above research, two kinds of figures are randomly selected according to the international standard of Braille, and the point distance in the international standard is taken as the size setting to make the basic model (Figure 13).

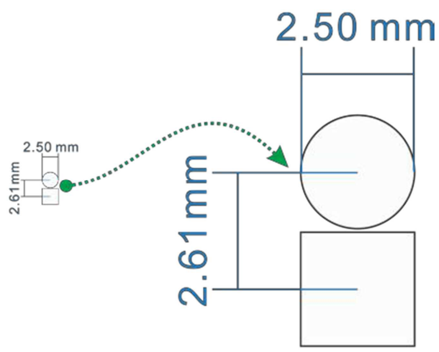


Figure 13. Figure size in accordance with Braille national standard

4.1.2 Graphic arrangement

The arrangement of the graphs is mainly used for experimental tests to test the problems that will occur in a type of person in the blind reading the graph and to collect and analyze the experimental data. The international Braille uses the changeable combination of six points to express the text, which is only used to express the text; there is no more requirement on the graphics, and the graphics performance has continuity, mainly used to express the painting works. The combination and arrangement of the graphics are closely related to the pixels of the painting works. In this case, the arrangement of the pictures has no square distance. Therefore, in consideration of the performance of color and learning cost in the future, the point spacing of graph sorting is executed according to the Braille international standard; according to the 11 graphs deduced, the point spacing between every two graphs should be arranged within 2.28~2.92mm to form the test graph, as shown in Figure 14.

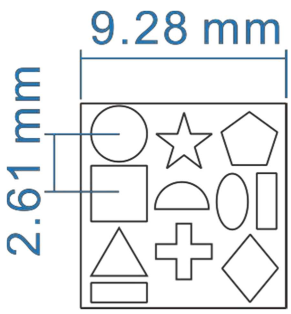


Figure 14. Arrangement and size of graphs

4.2 Experimental model making

The experimental model was made by two ways of 3D printing: SLA and FDM.

4.2.1 SLA

Stereo lithography Apparatus is mainly used for making a fine 3D model, and the unit can be accurate to about 0.1mm. On the premise of strict compliance with the international standard size of Braille, hundreds of graphic modules have been made through SLA, one of which is used for experimental tests. At the same time, the remaining number of graphic modules are used to expand the application, combined with the aluminum alloy carved outer frame, to form a practical model; this conceptual design has passed the international patent search (patent processing) and was selected into the 13th China National Art Exhibition. The National Art Exhibition is the most authoritative and largest exhibition in China's art circle. It is also a unique national art evaluation system, which holds a major event every five years (Figure 15).

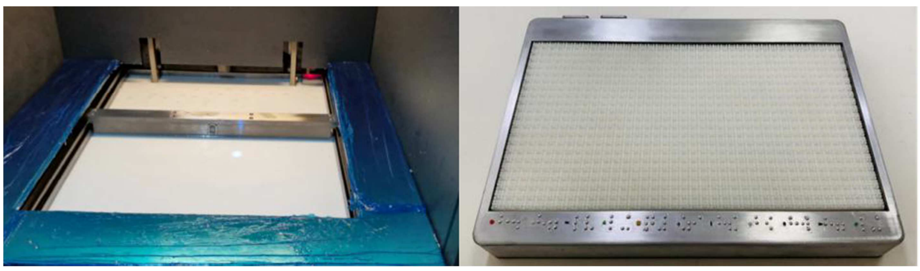


Figure 15. SLA 3D printing process and photo of finished model

4.2.2 Fused deposition modeling

According to the technical requirements of 3D printing of FDM, the image pixel analysis is done; taking the cartoon Iron Man cartoon as an example, the shape and color of iron man are represented by using shape instead of color (Figure 16).

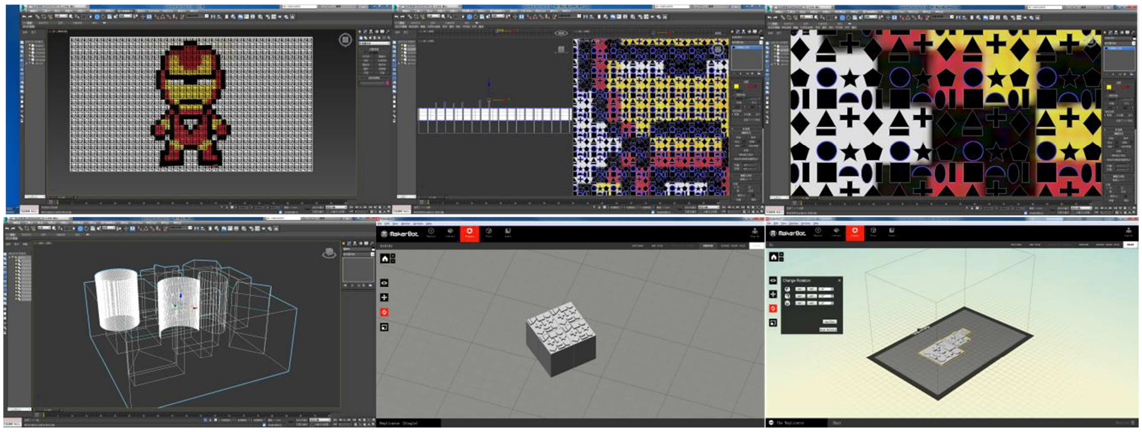


Figure 16. Image analysis using inductive graphics

It can be concluded from figure 16 that the way of replacing the color with the shape of graphics, the pixel is much higher than the existing way of replacing the shape with the color so that the shape and color of graphics can be better represented. This project is mainly to test the recognition of the figure by the blind, so only a single block graphic model was created in 3D printing.

In order to make the experiment more effective and comprehensive, under the premise that the point distance ratio conforms to the Braille international standard, the single block graphic model is scaled up by several values, namely: Braille international standard size, Braille international standard 1 time size, Braille International standard 2 times size, Braille international standard 3 times size, and then FDM 3D printing is carried out (Figure 17).

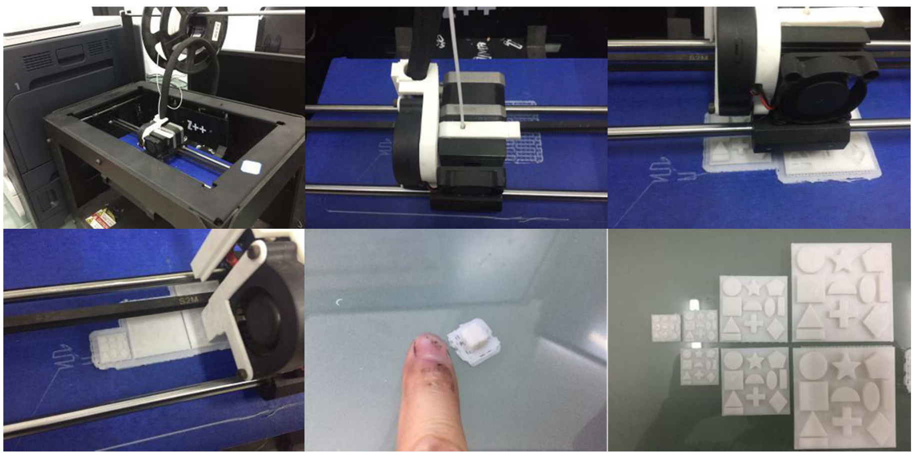


Figure 17. FDM 3D Printing process

4.3 Experimental design

The experimental target is postnatal blindness, < 0.05 ~ 0.02 (1.0-meter index), the third level of blind people, the second level of Braille, and the massage profession. A total of 15 people are tested according to different sizes of the model.

Group A: 15 people use Braille international standard size
Group B: 15 people use Braille international standard 1 time size
Group C: 15 people use Braille international standard 2 time size
Group D: 15 people use Braille international standard 3 time size

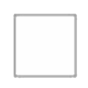
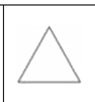
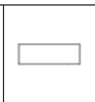
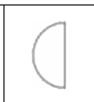
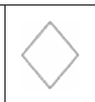
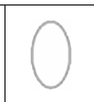
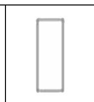
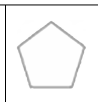
Before they start touch reading, explain to groups A, B, C and D what graphics are in the test graphic square, so that they can fully understand the shape range and match their touch reading advantages for testing (Figure 18).

Figure 18. Photos of field test

4.4 Experimental data analysis

While observing the experimental process, the characteristics of the four groups of experiments were analyzed: Inability to read the graphics, error-reading graphics and the problems in the process of reading. A form analysis based on experimental specific data was made (Table 2).

Table 2. Test data analysis

Groups	Average completion time of 15 people	Graphic shape reading result (Unit: per person)										
												
Group A	128s	1	0	0	0	0	0	0	0	0	0	0
Group B	73s	2	0	1	0	0	0	0	0	0	0	0
Group C	26s	15	13	13	15	6	5	6	3	3	13	3
Group D	18s	15	14	15	15	7	6	6	6	4	15	7

To help illustrate, the graphics are numbered (Figure 19).

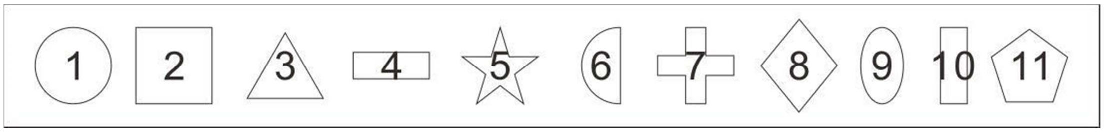


Figure 19. Process of numbering graphs

According to experimental data analysis and on-site interviews, the pixel sizes of Group C and Group D are most suitable; In the actual 3D model of the graph, under the premise of the same graph, the gap between the graph and the graph is very small, and it is easy to make a wrong judgment. Among them, No. 5 and No. 7, No. 6 and No. 9, No. 8 and No. 11 are the most obvious. According to the analysis results of the experimental data, the original 11 figures were adjusted (Figure 20).

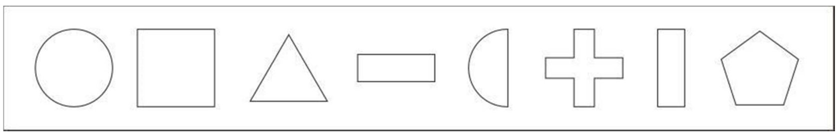


Figure 20. Graphs determined by test results

5. Conclusion

Through this research, it is found that the hearing and touch of the blind are more sensitive than the average person, and the research on the color of blind reading is relatively limited. In this research process, blind figure shape recognition is studied, which is a preliminary study on blind people's reading and painting works. Through the study of blind people, common graphic analysis and induction in daily life, on-the-spot investigation and national standards, the shape of the blind reading pattern is proposed. Through 3D printing technology, a single block model is made, and the model is used to test in a certain type of blind people. It is known that some figures are confused when blind people touch and read. According to the experimental test data and field interviews, 11 figures are adjusted. Through the final experimental data, 8 figures are determined to make the blind people touch and read quickly. In future research, the research of replacing the color with figure shape will be applied to blind painting exhibitions, blind teaching, blind art creation, blind film, social sharing, and other fields. We hope to help blind people open up new areas of touch reading through future research projects.

References

Conrad, L., Breakthrough assistive technology for the visually impaired, the official website of eSight technology company founded, https://esighteyewear.com (retrieved, 2006).

Estimates and trends in global blindness and visual impairment, Metadata analysis in the UK, https://www.sohu.com/a/166269255_377326 (retrieved August 21, 2017).

Harbison, N., Has become a government-recognised 'cyborg', http://www.chinadaily.com.cn/hqzx/2012-02/18/content_14637097.htm (retrieved February 18, 2012).

Huiying, S., Owen, E., Joshua, M. and James, M., Coughlan, "CamIO: a 3D computer vision system enabling audio/haptic interaction with physical objects by blind users", Published in: Proceeding ASSETS '13 Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility Article, 2014.

Juan, W., Zhenzhong, S., Weixiong, W., Liyuan, L. and Aiguo, S., "Design of image vibration tactile display system for blind people", Journal of Southeast University of China (Natual Science Edition), 2011.9.20.

Junyu, L., Meijing, C., Wenjun, Y., Jianlong, L. and Yuwen, L., Others invented tactile color communication system, http://youngpin100.com/t-c-c-s (retrieved April 23, 2015).

Louis, B., http://wikipedia.moesalih.com/Braille (retrieved, 1824).

Meng, W., Ziwei, W., Xiaowan, G., Lu, Z. and Yubing, G., "Bi perceptual design of color recognition system for blind people, Journal of China Education and teaching forum", No. 47, 2017.11.

National standard of the People's Republic of China, Chinese braille, GB/T 15720-2008, 2008.

Sagawa, K. and his students invented color tags that blind people could recognize, http://www.xinhuanet.com/world/2014-07/21/c_126779482.htm (retrieved July 21, 2014).

Santos, A., A cardboard system that allows blind people to "recognize" colors has been developed in Philippines, http://wlnews.zjol.com.cn/wlrb/system/2007/12/24/010279831.shtml (retrieved December 24, 2007).

SteelDesign Pharmaceutical Braille, https://www.pharmabraille.com/pharmaceutical-braille/marburg-medium-font-standard/ (retrieved, 2009).

Susan, O., Teaching Math to Students Who are Blind or Visually Impaired, https://www.perkinselearning.org/videos/webcast/teaching-math-students-who-are-blind-or-visually-impaired (retrieved, 2013).

World health organization (WHO) blind and low vision standards, http://2d.hep.com.cn/1611536/60 (retrieved, 1973).

Yang, J., Jiangtao, G. and Yingqing, X., "Graile Design of Blind Tactile Image Display", Chinese Decorative Journal Journal, 2016. 01.15.

Yupeng, F., Created the computer vision processing company official website, http://www.nextvpu.com/index_12.aspx (retrieved May 30, 2016).

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