Comparative Analysis Comprehensibility of Healthcare Symbols Between USA and China

Chuanyu Zou[1(✉)] and Guangxin Wang[2]

[1] AQSIQ Key Laboratory of Human Factors and Ergonomics (CNIS),
Beijing, China
zouchy@cnis.gov.cn

[2] Department of Psychology, School of Humanities, Beijing Forestry University,
Beijing, China

Abstract. With the tide of globalization getting ever higher and stronger, the need grows rapidly to travel aboard in order to obtain better health care. Hospital normally consists of many clinical departments and medical technology departments. It is difficult for patients to obtain medical information. Graphical symbols are helpful for patients who have limited ability to understand medical environment. In this study, 10 USA healthcare symbols from SEGD and 10 Chinese healthcare symbols from GB/T 10001.6 were conducted comprehension test. It was found that Chinese participants' average comprehension level on Chinese healthcare symbols is higher than that of American healthcare symbols. The study showed that the understanding of words, characters, etc. is highly correlated with the cultural background. They are not applicable as main element of a public information symbol. Furthermore, the respondents with higher education level have less difficulty than those with lower education level in comprehending graphical symbols.

Keywords: Comprehensibility test · Public information guidance system · Wayfinding

1 Introduction

1.1 Background

Due to the gradual increase of patients, hospitals are in a period of continuous expansion. The medical technology and medical environment of many hospitals have gradually become complicated. All modern hospitals will encounter a cyclical process after are built. Hospitals will be constantly remodeling and expanding, and new buildings slowly integrated with the entire medical environment. They hope to resolve the contradiction between the advancement of medical technology and the original built environment.

Moreover, with the tide of globalization getting ever higher and stronger, the need grows rapidly to travel aboard in order to obtain better health care. As a special crowded public place, hospital normally consists of many clinical departments and

medical technology departments, so the building structure is very complex. Under the pressure, anxiety and tension, it is difficult for patients to find their target floors or departments especially in a foreign hospital. A reasonable and effective wayfinding system becomes especially important.

Public information guidance system is an information system that guides people to locate in public places, understand their location, and be free to move. Its main role is the guiding role, that is, "guidance." The hospital public information guidance system is not only a supplementary explanation for the design content of the architectural environment, nor is it merely a symbolic semiotics and communication content in the visual communication discipline. It is an indispensable, irreplaceable important part in an environmental space. Belonging to a complicated marginal interdisciplinary subject, the public information guidance system contains the characteristics of the architectural engineering framework and the characteristics of artistic design in a complex environmental space. This requires strengthening the overall planning of the public information guidance system in the specific public environment of the hospital. The ultimate goal is to eliminate the barriers of language and culture through the effective guidance, and better promote the harmony between the public environment and people.

Among many wayfinding aids, graphical symbols are helpful for those patients who have limited ability to communicate in local language. Graphical symbol is a visually perceptible figure with a particular meaning used to transmit information independently of language.

1.2   Current Status of Relevant Standards

A national standard system on public information guidance systems has initially established in China. It consists of 26 standards in three categories, information element standard, guidance element design standard and system setting standard, namely GB/T 10001 "Public information graphic symbol" [1], GB/T 20501 "Public information guidance system– Design elements and requirements" [2], GB/T 15566 "Public information guidance system– Setting principles and requirements" [3]. Among them, GB/T 10001.6 "Public information graphical symbols for use on sign-Part 6: Symbols for medical treatment and health care", specified 43 medical and health-related standardized graphic symbols such as "emergency", "outpatient" and "pharmacy". According to the medical treatment process, GB/T 15566.6 "Public information guidance systems - Setting principles and requirements - Part 6: medical site" standardizes the setting of the guidance elements at the key nodes of the hospital's wayfinding system.

ISO/TC 145 has developed ISO 7001 "Public information graphic symbols" [4], which specifies 168 standardized graphical symbols. Among them, the medical related graphic symbols include "Hospital" and "Dentist". The organization has also developed ISO 28564 "Public information guidance systems" standard [5], giving design guidelines for guiding elements such as guiding signs and position signs.

1.3   Current Research Status

In October 2010, Society for Experiential Graphic Design (SEGD) proudly introduced a universal set of healthcare symbols, developed in collaboration with Hablamos Juntos [6], including 54 graphical symbols, e.g. "Inpatient", "Outpatient".

Yang et al. [7] conducted a satisfaction survey on 1060 outpatients and inpatients in the public information guidance system of the hospital. The study found that the patient was dissatisfied with the hospital's public information guidance system, the reasons related to the patients, the staff, the unreasonable design of the signs, the complexity of the content, and the lack of conspicuousness. The study suggests that the hospital's public information guidance system should be simple and easy to understand, and use graphical symbols to convey information directly, so that patients with low education background can understand it.

Hong et al. [8] conducted a study on the public information guidance system of hospitals in Taiwan. Taiwan's hospitals used a large number of simple and easy-to-understand images in the design of signs, which played a very good indication and conciseness. The systems design has the advantages of conciseness, standardization, artistry and humanity. The scientific concept, normative and people-oriented design concepts and measures of Taiwan hospital wayfinding systems are worth learning and promotion.

Lee et al. [9] tested universal healthcare symbols in the United States, South Korea, and Turkey to compare the comprehension of symbols cross-country and identify predictors of the correct comprehension.

2   Methods

2.1   Objects

ISO standardizes a series of standardized test methods for graphical symbols in ISO 9186, in which ISO 9186-1:2014 [10] specifies a method for testing graphical symbol comprehension, ISO 9186-2:2008 [11] specifies a graphical symbol for the perceptual quality test method. ISO 9186-3:2014 [12] specifies the symbol referent association test method. This paper uses the graphical symbol comprehension test method specified in ISO 9186-1:2014 [10], conducted comparative analysis on the comprehensibility of healthcare symbols between USA and China.

In this study, 10 USA healthcare symbols from SEGD were tested (Fig. 1 with black background), including Emergency, Pharmacy, Obstetrics and gynecology department, Pediatrics department, Pathology department, Operating room, Radiology department, Patient file room, Electrocardiographic room, Prevention and health protection department. 10 Chinese healthcare symbols (Fig. 1 with white background) with the same meaning were also tested. About 200 respondents were involved.

2.2   Participants

A paper questionnaire was used to conduct the comprehension test. 200 questionnaires were distributed and 164 valid questionnaires were collected, with a recovery rate of
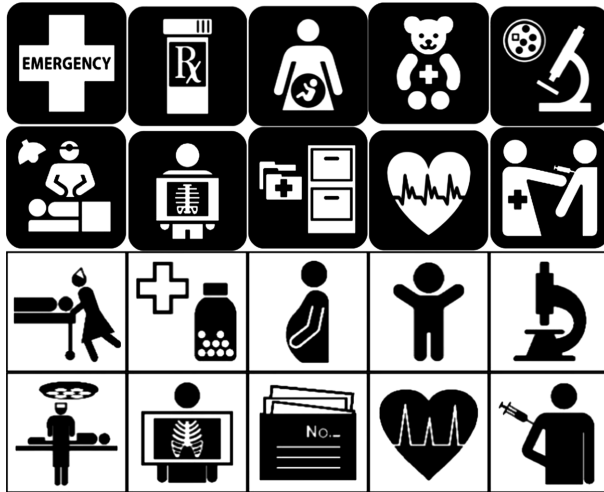
Fig. 1. 20 healthcare symbols from SEGD and China

82%. Demographic variables are age, gender, and education, basic information of the participants is shown in Tables 1, 2 and 3. "Age" is divided into three categories, 15–30 years old, 31–50 years old, 51–70 years old (see Table 1). "Gender" is divided into two categories (see Table 2). Level of education is divided into four categories: primary or secondary, specialist or technical schools, universities (including reading), graduate students and above (see Table 3).

Table 1. Age distribution of participants

Age	Number	%
15–30	88	53.66
31–50	56	34.15
Above 50	20	15.19

Table 2. Gender distribution of participants

Gender	Number	%
Male	64	39.02
Female	100	60.98

2.3   Test

Test Questionnaire. The questionnaire includes comprehension tests for 10 USA healthcare graphic symbols and 10 Chinese medical graphic symbols. Each graphic symbol has one test page. Each page included a description of the expected location of

Table 3. Level of education distribution of participants

Category	Level of education	Number	%
1	Primary or secondary school	40	24.39
2	Specialist or technical school	30	18.29
3	University (including undergraduate)	86	52.44
4	Graduate and above	8	4.88

the graphical symbol, and the question to be respond, the graphical symbol itself and the actual application scenario of the graphical symbol to be tested. Each healthcare graphical symbol was set in 50 mm × 50 mm square. At the bottom of the entire page is the test respond area, marked with a rectangular frame. Participants were asked to fill their responds into the rectangular box below the graphical symbol (that is, the meaning of the graphical symbol). If participants did not know the responds, fill in the blank with "Don't know." In order to prevent the sequence effect, the whole set of questionnaires is not numbered and the order was set.

Test Procedure. The comprehensibility test of 20 healthcare graphical symbols was conducted in the Institute of Human Factors and Ergonomics lab in China National Institute of Standardization. After arriving at the laboratory, participants signed the informed consent and completed self-report page about their demographic information. Show an example page of a commonly known public information graphical symbol and confirm that all participants say that they understand their task. All participants were required to complete the test independently by reading and filling the test pages one by one.

Data Collection. All participants filled in the answers in the blank space below the graphic symbol. The scoring standards are shown in Table 4.

Table 4. Scoring standards

Category	Meaning
1a	Completely correct
1b	Approximate correct
2a	Wrong
2b	Wrong and opposite
3	Do not know
4	No response

Since the responses of the participants are all in text, first the answers with similar meanings should be classified, and then standardize the answers into relative categories. Take the first question as an example: fill in with "emergency", "emergency room", "emergency treatment" and "emergency first" and so on as "emergency", that

is, completely correct, classified as category "1a"; fill in with "do not know" as category "3".

3   Test Result

According to ISO/TC 145, the criterion of acceptability on the comprehension test is that the percentage of responses in category 1 (correct, including complete correct and approximate correct) shall be 66% or over [13]. Cross tabulation of the results from comprehension test for 20 Chinese and USA healthcare graphical symbols was developed (Table 5).

Table 5. Cross tabulation of 20 healthcare graphical symbols comprehension (unit: % of correct responses reported).

	Emer	Phar	Obst	Pedi	Path	Oper	Radi	Pati	Elec	Prev
CHN	83.3	96.6	98.9	92.0	44.8	81.0	78.7	69.5	97.1	93.7
USA	58.7	53.9	95.2	89.2	41.3	71.3	79.6	47.9	95.2	85.6
Aver	71	75.25	97.05	90.6	43.05	76.15	79.15	58.7	96.15	89.65

9 out of 10 Chinese have comprehension rates higher than the criterion of acceptability by ISO standard (see Table 5). They are Emergency (83.3%), Pharmacy (96.6%), Obstetrics and gynecology department (98.9%), Pediatrics department (92.0%), Operating room (81.0%), Radiology department (78.7%), Patient file room (69.5%), Electrocardiographic room (97.1%), Prevention and health protection department (93.7%).

6 out of 10 USA healthcare symbols have comprehension rates higher than the criterion of acceptability by ISO standard (see Table 5). They are Obstetrics and gynecology department (95.2%), Pediatrics department (89.2%), Operating room (71.3%), Radiology department (79.6%), Electrocardiographic room (95.2%), Prevention and health protection department (85.6%).

It is shown that Chinese participants' average comprehension level of Chinese healthcare symbols (83.56%) is higher than that of American healthcare symbols (71.79%).

Among 20 graphical symbols, the comprehension test scores of six graphical symbols simultaneously reached the criterion of acceptability on the comprehension test of ISO. They are Obstetrics and gynecology department (average 97.05%), Pediatrics department (average 90.6%), Operating room (average 76.15%), Radiology department (average 79.15%), Electrocardiographic room (average 96.15%), Prevention and health protection department (average 89.65%). These graphical symbols have a common feature of the department: the functions and features of the diagnosis are widely understood and easily identifiable.

The graphic symbol with the lowest understanding score is "Pathology department" (average 43.05%). The Department of Pathology is one of the important departments of large-scale hospitals. Its main task is to undertake pathological diagnosis in the medical

process, including through biopsy, exfoliation and puncture cytology to provide a clear pathological diagnosis for the clinic and determine the nature of the disease. In China, the patient or relative's contact with the pathology department is taking the pathology of the tissue specimen from the patient to the department, and then retrieving the pathological diagnosis report at the prescribed time. The patient does not understand the working environment of the pathology department or the main pathology work.

The design of the graphic symbols of the pathology department came from the main detection tool, microscope, of the pathology department. The symbolic element of the pathological slice added to the American graphic symbols. Since the participants do not understand the working environment of the pathology department or the main testing work, it is natural that the comprehension test score is the lowest.

The graphical symbols with the highest level of comprehension are Obstetrics and gynecology department (average 97.05%), Electrocardiographic room (average 96.15%). The designs of two graphic symbols "Obstetrics and gynecology" all come from the figure of a pregnant woman. Among them, the Chinese one uses the side view of pregnant women as symbolic elements, and the Americans one use the front view of pregnant women as symbolic elements. The designs of two graphical symbols "Electrocardiographic room" use the heart figure and the electric wave as the main symbol. The functions and features of the two departments are widely understood and easily identifiable, so the high scores of comprehension test are naturally.

4   Analysis and Discussion

4.1   Chi-Square Test in Chinese Healthcare Symbols

Chi-Square Test of Age Difference. The researchers conducted a chi-square test on the difference of Chinese healthcare symbols in terms of age. From the results of the chi-square test, the Chinese healthcare symbols did not have an age difference in comprehension.

Chi-Square Test of Education Level Difference. The researchers conducted a chi-square test on the difference of Chinese healthcare symbols in terms of educational level. From the results of the chi-square test, the test results of different healthcare symbols are quite different. 9 out of 10 Chinese healthcare symbols did not find any difference in education level in comprehension test. "Obstetrics and gynecology department" graphical symbol was found to be associated with education level. The chi-square value is 17.054, and the sig value is 0.009, which has reached a significant level of 0.01, indicating that the education level does have an impact on the understanding of "Obstetrics and gynecology department" graphical symbol. In category "1" (correct), the correct rate of comprehension with education level "3" and "4" was 88.3%. In category "2" (wrong), the error rate of comprehension with education level "2" is 9.5%, which is much higher than the average error rate 3.3%. In the "I don't know" answer, the rate with education level "1" and "2" was 10.2%, which was also higher than the average rate of 8.0%. Of course, the reason for the relationship between the graphical symbol and education level may also be influenced by the sample

distribution, that is, the sample of error rate in the sample distribution is small, which may affect the chi-square test results.

4.2 Differences in Understanding of Chinese Participants on Two Sources of Healthcare Graphical Symbols

Chinese participants took part in the comprehension test on Chinese and USA healthcare graphical symbols. The comprehension test scores of two graphical symbols differed significantly (see Table 5), e.g. "Emergency" (CHN 83.3%, USA 58.7%), "Pharmacy" (CHN 96.6%, USA 53.9%). Checking response category data of 1–4 (see Table 6), it is found that the difference between the graphical symbol "Emergency" and the graphical symbol "Pharmacy" was mainly due to the fact that a large number of participants did not know the meaning of the graphical symbols (22.8% and 37.7%, respectively). The main reasons for "Don't know" filled by participants were "do not understand the meaning of words" and "do not understand the meaning of characters." The main symbolic element of the American graphic symbol "Emergency" is the cross and the English word "Emergency", while the main symbolic elements of the graphic symbol "Pharmacy" is transparent lid containers and English letters (P is the first letter of Pharmacy). ISO 22727:2007 [14] specifies the characters used in the design of graphic symbols: "Letters, numbers, punctuation marks, mathematical symbols, and other characters shall be used only as an element of a public information symbol." The reason is that the understanding of words, characters, etc. is highly correlated with the cultural background, and does not conform to the principle of graphic symbol design "understanding is not affected by language and cultural barriers."

Table 6. Comprehension test data of Emergency and Pharmacy

Category	Emer	Phar
1	58.7	53.9
2	18.6	8.4
3	22.8	37.7
Total	100	100

4.3 Relationship of Graphic Symbol Design and Comprehension

In ISO 22727:2007 [14], it is required that graphical symbols be readily associated with its intended meaning. The best way to design graphical symbols is based on objects, activities, etc., or a combination of these, which are reliably identifiable by the target audience. According to the design features, graphical symbols can be divided into two types: abstract symbols and concrete symbols.

The comprehension scores of those two types were listed in Tables 7 and 8. If both symbols (CHN and USA) are concrete symbols, the average correct response is used.

It is obvious that most symbols are concrete symbols (only one abstract symbol), design elements like objects and activities are used to form the figure.

Table 7. Cross tabulation of concrete symbols (unit: % of correct responses reported)

CHN-Emer	Aver-Phar	Aver-Obst	Aver-Pedi	Aver-Path	Aver-Oper	Aver-Radi	Aver-Pati	Aver-Elec	Aver-Prev	**Total-Aver**
83.3	75.25	97.05	90.6	43.05	76.15	79.15	58.7	96.15	89.65	78.91

Table 8. Cross tabulation of abstract symbols (unit: % of correct responses reported)

USA-Emer	**Total-Aver**
58.7	58.7

The average correct response of concrete symbols is 78.91%, which is much higher than that of abstract symbols (58.7%). By analyzing the design of abstract symbols and concrete symbols, the root causes of the differences between the comprehensibility scores of them can be further understood.

An abstract symbol is constituted by graphic elements unrelated to the apparent or activity characteristics of the object being referred to. While a concrete symbol is designed with graphic elements extracted from the apparent or activity characteristics of the object being referred to. Also taking the two symbols of "Emergency" to illustrate. The Chinese symbol of "Emergency" is a concrete one which formed by a nurse's side portrait who is pushing a cart. This design comes from the routine work of emergency rooms: a nurse pushed the emergency patient to the treatment room with a cart. The USA symbol of "Emergency" is an abstract one which formed by a cross figure and the English words "Emergency". The cross is derived from the Red Cross and represents medically relevant meaning. From chi-square test USA symbol of "Emergency" was found to be associated with education level. This also verifies the principle of graphic symbol design principles in ISO 22727, that is, the design of graphic symbols is intuitive and easy to understand, and not affected by language and cultural barriers.

5   Conclusion

Graphic symbols play an increasingly important role in the complex modern architectural environment. The design of graphical symbols should fully consider the prominent features of its information transmission across the language and culture barriers, and use elements that are intuitively related to the reference objects.

The test results showed that concrete symbol is easier to be understood than abstract symbol. According to test results of two different variants of "Emergency", it shows that concrete symbol are more likely to be understood correctly than abstract one. It was also found that Chinese participants' average comprehension level on Chinese healthcare symbols is higher than that of American healthcare symbols, which means through education and learning, the comprehension of graphical symbols can be effectively improved.

The study found that the respondents with higher education level have less difficulty than those with lower education level in comprehending graphical symbols.

Results of this study demonstrate that symbol comprehension can be influenced significantly by the design and respondents' education level.

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