Industrial Cognitive Ergonomics and Engineering Psychology, Vol. 35, 2022, 101–107
https://doi.org/10.54941/ahfe1001608

The Relationship Between Simplified Chinese Character Height and Cognition Research in Signage Design

Duan Wu[1], Peng Gao[2], Dongying Hu[1], Ran Xu[1], Yue Qi[1], and Yumeng Zhang[3]

[1]College of Design & Innovation, Tongji University Shanghai Institute of Design and Innovation, Shanghai, 200092, China
[2]Shanghai Tenth People's Hospital, Shanghai, 200092, China
[3]Capital University of Economics and Business, China

ABSTRACT

75% of our external information comes from vision, in signage and wayfinding system, characters and graphics have become the most important factor of information cognition. As the main characters in China's signage and wayfinding system, simplified Chinese characters affect the rapid and accurate cognition of information. In order to obtain the data that can really guide the standards of signage design in China, this research carried out a series of experimental studies on simplified Chinese characters' recognition. Under the condition of fixed font, font weight, color, similar stroke number and character frequency range, the experiment obtained the data of characters' height and recognition distance by changing characters' height and recording the corresponding visual recognition reaction time. Then, based on the method of regression analysis, the relationship between the two variables of character height and recognition distance is calculated and visualized. Through indoor simulation and supplementary experiments, the data and conclusions could guide or verify the existing ergonomics data and signage design standard. The research outcome shows the relationship between simplified Chinese character height and cognition distance of public signage system, which provides a theoretical basis for the related research and design. The results also revealed that with the use of Sans Serif typeface, the minimum of character height in the current design standard can be further increased. This research is still in early stage, in addition to the character height, the influence of stroke number, thickness and background color contrast of characters still need to be further studied.

Keywords: Character height, Cognition distance, Signage system, Simplified Chinese

INTRODUCTION

"Signage" refers to the design or use of signs and symbols to communicate a message to users through vision, hearing, touch or other media in a built environment. Since 75% of human's perception of external information comes from vision, the text and graphics in signage system have become the very important factor of information exchange. As the main text used in China's signage system, Simple Chinese characters affect the rapid and accurate transmission of information.

Many countries have researches on character recognition, and the national standard for characters has been formulated accordingly. While most of the cognitive research on simplified Chinese characters are learned from the data of Japan and Taiwan. Compared with Latin alphabets, Japanese and Chinese characters are much similar, but there are still significant differences between them. Japanese is a combination of Chinese characters and Kanas, the fonts and the layout of characters are very different. The traditional Chinese characters used in Taiwan are much more complicated than the simplified ones used in mainland China.

The Highway Science Research Institute of China Ministry of Transportation has published a series of research results on the character height, character spacing, height width ratio and stroke thickness of Simple Chinese characters used in traffic signs (GB5768-1999). However, the standard is only applicable to traffic system, which is aimed at drivers in the process of high-speed driving, and is not applicable to pedestrian signs in public space.

Therefore, when participating in the authoring group of the national standard of the people's Republic of China "Technical code for signage system of public buildings", the author carried out a series of experimental research in order to verify or calculate the relationship between the character height and the cognition distance in signage system.

The experiments recorded in this paper attempts to use scientific, reasonable and effective research methods to carry out the research on simplified Chinese character recognition. The objective is to obtain the relationship data between character height and recognition distance of public signage system for Chinese pedestrian users, so as to guide or verify the future design.

METHODS

In the experiment, under several fixed reading distances, the volunteers were given different text height with random content on the page. The decline and minimum value of text height were obtained by recording and analysis the time and accuracy of their recognition, and with these data, the critical and recommended values could be calculated.

Influencing Factors of Character Recognition

In addition to the height of a characters, there are many other factors that affect the text recognition in signage system, such as typeface, aspect ratio, stroke thickness, contrast with the background etc (Table 1). This experiment only tests the relationship of Simplified Chinese character height with recognition distance; therefore, a single factor multi-level experimental test is adopted to keep other factors as a fixed amount.

According to the literature review, the recognition distance of boldface texts (without decorative line) is the best in the same distance. At the same time, in China's current national standard GB5768-1999, signage system is required to use boldface for Simplified Chinese characters. Therefore, boldface is used as the fixed factor in this experiment.

Table 1. Influencing factors in the experiment.

Influencing Factors	Ration/Variable	Set Value
Typeface	Ration	(Sans-serif) boldface
Stroke number	Ration	5–10
Color	Ration	Black text on white background
Information in one page	Ration	6 street names on one page
Text Hight	Variable	
Distance	Variable	

Table 2. Participants' gender and age distribution.

	Age			
Gender	18–33	34–49	Over 50	Total
Male	11	8	6	25
Female	9	12	4	25
Total	20	20	10	50

Experimental Equipment and Participants

- Tobii Glasses Head mounted eye tracker(Tobii Technology Inc), used to track the eye's movement and its corresponding residence time
- Tobii studio analysis software is used to record the scanning position and analysis the identification range
- Projector (high precision)
- Photography and camera equipment
- Computers and peripherals

Relevant studies show that there are differences in response time between men and women of the same age, and the same for age differences (Table 2). Therefore, this experiment selects 50 participants of different genders and across all ages, requiring all participants to have corrected vision of more than 4.8, non-color blindness and no visual diseases.

Experimental Scheme

Research shows that the difference between the static recognition and the dynamic recognition distance is very small within the speed of 120km/h (Hou DZ., Huang K., Han WY., 2010). Therefore, our experimental premise is:

(1) When the speed is below 120km / h, dynamic vision = static vision. (research results from the Western Transportation Construction Science and technology project 200431822333-10 of the Transportation Ministry of China).
(2) The visual recognition distance s of human eyes is related to the viewing angle and object height H, that is, the recognition distance S is directly proportional to the height H:

$$H = 2 \cdot S \cdot tg\frac{a}{2} = 2tg\frac{a}{2} \cdot S = k \cdot S \rightarrow S = \frac{1}{k} \cdot H$$

(3) Visual recognition reaction is regarded as effective within 2.5 seconds.
(4) The selected typeface is boldface, and the stroke thickness is 1/14 of the character height.

The experimental viewing angle is 15 ° upward.

Experimenters measure the participants' recognition time for finding the target information among six message bars. If the visual recognition reaction is within 2.5s, it is regarded as effective recognition. Repeat the experiments by changing the parameters of recognition distance and characters height separately to obtain the variable.

Taking the "Chinese character frequency table" from the Modern Chinese Frequency Dictionary published by Beijing Language and Culture Institute Press as the thesaurus, we selected the high-frequency Chinese characters in the word frequency serial number 1-400 as the benchmark for the recognition experiment. After eliminating those ones that are not suitable for the road name and do not meet the stroke requirements, we finally selected 153 Chinese characters with different structural forms, different use frequencies with relatively balanced structural of 5-10 strokes. We randomly choose two characters combining into one road name, which is taken as one message bar, forming a total of 77 message bars. According to previous studies, when the information is no more than 6 messages on one surface, the cognitive time about 2.43s, rounded to 2.5s. Therefore, the amount of information in each page is fixed as 6 road names, and the line spacing is fixed at 0.6h (Note: H is the height of Chinese characters).

A special program is written for the experiment. After playing, the target message and the recognition page will be appeared on the screen in turn. The participants are required to identify whether the target message appears in the page within 2.5s, and click a button to confirm after finding the target information. After 2.5s, the program will automatically switch to the next page. Whether the participants click the button or not, the corresponding word height data will be recorded automatically in the program. If the subjects confirm that there is no target information in the 6 road names, they will say "no" and be recorded by the experimenter.

In the experiment, there will be a 2s blank between each page, and one landscape picture will be shown after every 5 pages to alleviate the fatigue of the participants. After the experiment, the record of eye tracker data was used to verify the recognition's reliability. We also ensure that the ambient brightness conditions of the lab are consistent in the experiment (Figure 1).

Experimental Results

Finally, 144 valid experiment data were collected and analyzed. After review the eye tracking data, the influence of confidence is removed. The average accuracy rate of each word in the experiments and the average time spent by the right respondent are analyzed. While the critical value of character height is generally lower than expectation, a serious of supplementary experiments are implemented to narrow the scope and obtain more accurate data. Final data are shown in Table 3.

Figure 1: The experiment processes.

Table 3. Sample human systems integration test parameters.

4 meters distance				6 meters distance			
H(cm)	Accuracy quantity	Average accuracy	Average time(s)	H(cm)	Accuracy quantity	Average accuracy	Average time(s)
8	47/47	100%	1.5749	8	45/47	95.74%	1.3054
6	47/47	100%	1.4385	6	46.5/47	98.94%	1.3220
4	44.5/47	94.68%	1.2940	4	45.5/47	96.81%	1.2326
3.5	42.5/47	90.43%	1.3009	3.5	45/47	95.74%	1.3879
3	45/47	95.74%	1.4695	3	41.5/47	88.29%	1.6045
2.5	39/47	84.04%	1.9018	2.5	42.5/47	90.43%	1.5719
2	28.5/47	60.64%	1.9937	2	18.5/47	39.36%	1.7263
8 meters distance				**10 meters distance**			
H(cm)	Accuracy quantity	Average accuracy	Average time(s)	H(cm)	Accuracy quantity	Average accuracy	Average time(s)
10	47/48	97.92%	1.2979	10	47/49	95.92%	1.2240
8	46.5/48	96.88%	1.1474	8	48/49	97.96%	1.2631
6	45/48	93.75%	1.6342	6	47/49	95.91%	1.0967
5.5	47/48	97.91%	1.2748	5.5	47/49	95.91%	1.3052
5	46/48	95.83%	1.5067	5	48/49	97.96%	1.5338
4.5	45/48	93.75	1.5357	4.5	46/49	93.88%	1.7159
4	42/48	87.50%	1.4122	4	36/49	73.47%	1.0967

FINDINGS

After regression analysis of the data in Table 3, it is found that if the critical value of H is judged by the value with the largest increase in time, it can be fitted into the linear equation $y = 0.615x+0.307$, where x is the recognition distance (meter), y is the minimum recognition character height (cm), and the judgment coefficient $R^2 = 0.8$. This indicats that 80% of the relationship between the Simplified Chinese character height and the static observation distance can be explained by the linear relationship.

The fitting effect of the relationship between the height and distance of the regression model is acceptable, and it is relatively consistent with the linear trend of the values in the specification (Fig. 2). If the critical value of word

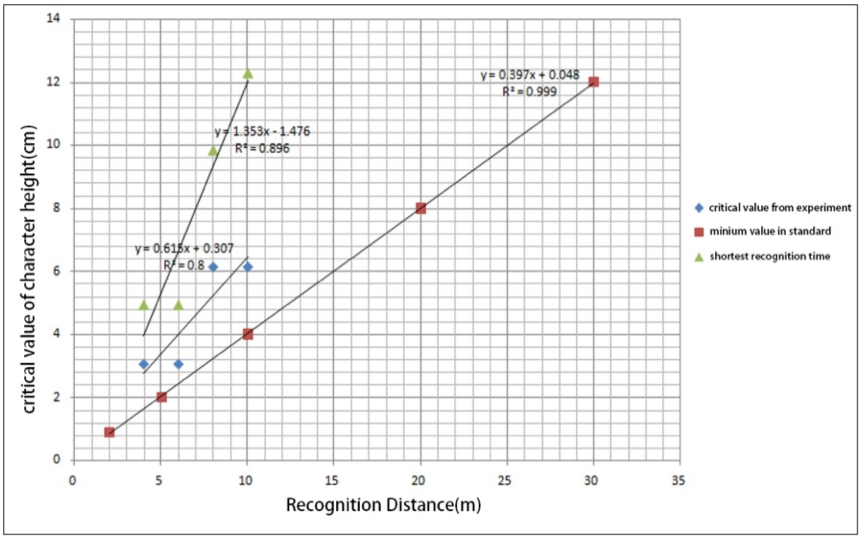

Figure 2: Relationship analysis of experimental data.

Table 4. Minimum and limit character height relationship with distance.

Observation distance (m)	Limit value of character height (cm)	minimum value of character height (cm)
1≤L≤2	1.6	1.6
4≤L≤5	3.4	5.3
L≤10	6.5	12.0
L≤20	12.6	25.6
L≤30	18.8	39.1

height is judged by the best value with the shortest time, it can be fitted to the linear equation y = 1.353x-1.476, R^2= 0.896.

Through the above analysis, it can be found that there is a good correlation between the height of Simplified Chinese characters and cognition distance. With the increase of cognition distance, the minimum value of character height should also be increased accordingly. Due to the limitation of experimental conditions, it can be concluded that the growth trend of the critical value of Simplified Chinese character height is relatively uniform within 10 meters. At the same time, we believe that the minimum value of Chinese character height in the earlier draft specification (GB/T18574-2008) is mainly based on the data from Japan. Because Simplified Chinese characters are more complex, the critical value data from the experiment is larger. Based on that, we propose an optimization minimum value for the relationship (Table 4).

CONCLUSION

Through experiments, this research studies the relationship between Simplified Chinese character height and recognition distance of public signage system, which provides a theoretical basis for the related design and the national standard compile. The experimental results show that on the basis of using boldface typeface characters, the limit value of word height specified in the current Public Signage Design Standard in China need to be further improved.

While the research is still in early stage, in addition to the factor of character height, the influence and comprehensive effect of stroke number, stroke thickness, color contrast and other factors of Simplified Chinese characters also need to be further studied.

FUNDING

This research was supported by the National Natural Science Foundation of China (project No.51708412).

ACKNOWLEDGMENT

The authors would like to acknowledge the support from Tongji University and Shanghai Municipal Engineering Design Institute (Group) Co., Ltd.

REFERENCES

Hou Dezao, Huang Kai, Han Wenyuan. (2010) Research on the Height Model of Chinese Signage Based on Driver's Cognitive Characteristics. Highway Transportation Technology, Volume 3.

Jiang Haifeng, Han Wenyuan, Zhang Zhiyong. (2009) Study on the Relationship Between Word Height and Visual Recognition of Traffic Signs, Highway Transportation Technology, Volume 26 No. 7.

Shi Xiuhong. (2010) Study on the Relationship Between Font Selection and Visual Recognition of Traffic Signs. Kejifeng, Volume 3.

The American Heritage Dictionary of the English Language (Fourth ed.). Houghton Mifflin Company. 2000.

Yu Lin, Xiaodong Pan, Shouen Fang. (2005) Study on the Relationship Between the Amount of Information and Cognition of Traffic Signs. Journal of Transportation Engineering and Information, Volume 03.

Zhang Boming. (1993) Study on the Visual Recognition of Chinese Characters in Traffic Signs. Highway Transportation Technology, Volume 2 No. 2.