The Effects of Age, Viewing Distance and Font Type on the Legibility of Chinese Characters

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Abstract. This study evaluated the effects of age (30s and 55s), viewing distance (50 cm, 80 cm), font type (Lanting in simple, Lanting in complex, Yahei in simple, Yahei in complex) on the legibility of Chinese characters by using the two legibility measures (minimum character size for 100% correctness and minimum character size for the least comfort). Twenty subjects in each age group read the 12 word groups (two characters in each word group, character size varied from 4.5 pt to 18 pt) presented on a paper. Subjects subjectively rated the reading legibility of the word groups on a 3-point scale (1- indistinct, 2- distinct but need cost a little attention, 3- very distinct). According to the ANOVA procedure, age and viewing distance significantly affected the two dependent variables ($p < 0.05$). The younger group could see character sizes smaller than the old group could and the viewing distance of 50 cm showed character about 1pt smaller than those at a 80 cm viewing distance. There are no significant differences in font types. From a comparison of the results for correctness and comfort, people generally preferred larger character sizes to those that they could read. The findings of this study may provide basic data and guidelines for setting of character size and font type to improve the legibility of characters written in Chinese.

Keywords: age, viewing distance, font type, Chinese character.

1 Introduction

The legibility and readability of characters are important to our daily activities and tasks. If the sizes of the characters are too small or poorly designed, people may not obtain the correct information. The main factors which affect legibility are font size, type of font, thickness of font, space between fonts, contrast of colors, distance of sight, illumination and so on. Many researchers have studied the effects of font size, font type, viewing distance, age and contrast to the legibility of characters.

In a study of font sizes, Wang Jian et al. found the complexity of Chinese characters influence the Chinese character threshold [1].Zhou Aibao et al. explored processing

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speed influenced by the font, size, and characteristics of Chinese character [2]. The results show that among seven kinds of fonts, processing speed of Sungti, Zhengkai and Heiti is faster than that of Xingkai, Lishu, Weibei, and Caiyun. Japanese researchers have provided a standard for the various font sizes of Japanese characters in visual displays to make them legible to older and visually impaired people [3]. The US also has a standard on character sizes for the labeling of medical supplies [4].

Font type is also a significant factor for the legibility of words in hard copy. Wang You et al. measured the character recognition threshold or acuity of Chinese characters [5]. The results show that four types of Chinese character fonts (Songti, Heiti, Kaiti and Fangsong) have different acuities: Heiti being the smallest, Kaiti larger, and Songti and Fangsong the largest. The Gothic fonts were smaller than the Ming fonts in Korean users' visual performance which tested two age groups (20s and 60s) for different font types of Korean letters and numbers at 50 cm and 200 cm viewing distances respectively [6]. An experiment was conducted to compare with recognition accuracy of four fonts, of Chinese characters under three various back illumination [7]. The results show the Song font and Black font were better than imitative Song font and Long Song font, and Long Song font was worse than imitative Song.

Age and viewing distances are main factors to affect the legibility of characters, but most studies of the effect factors for Chinese character are focus on the font, size, stroke and structure. Therefore, this study investigated the effects of age and viewing distance on the legibility (correctness) and subjective preference (comfort) of Chinese characters associated with different age groups. The objectives of this study were to: (1) provide guidelines for the minimum Chinese character size for 100% correctness; (2) suggest guidelines for comfortable Chinese character size on the basis of the age of the person.

2 Methods

2.1 Subjects

In all, 40 participants, comprising 20 young people (in their 30s) and 20 elderly people (in their 55s) were recruited, respectively, to investigate legibility in relation to age. The mean age and mean visual acuity of the young participants were 32.85 (±6.05) years and 0.84 (±0.15) respectively, whereas the mean age and mean visual acuity of the elderly groups were 56.90 (±4.15) years and 0.36 (±0.15), respectively. All subjects were tested and selected by a Landholt acuity test with a 30 cm distance measure. All participants were native Chinese speakers. None was color blind or had eye defects.

2.2 Procedure

Before the experiments, the personal data of the participants was asked. Then all participants were provided with a brief description of the goals and procedures of this study. The illuminance level was measured and recorded and to confirm it was in an appropriate range at the surface on which the test charts will be placed. And each participant's visual acuity was tested.

After the visual acuity test, each participant was asked to try to read characters presented on papers and determine the reading legibility of the word groups. And the

participants rated the legibility by using a 3-point scale (1- indistinct, 2- distinct but need cost a little attention, 3- very distinct). The numbers of correct/wrong answers as well as the subjective reading legibility ratings of each character group were recorded. If a participant provided all wrong answers for the two characters twice consecutively, the experimental trial was stopped. After a trail, participant needed to report the least comfort character group depending on character size.

The measurement of the dependent variables were as follows: (1) 'minimum character size for 100% correctness', which was defined as the smallest font size among character sizes at which the participant correctly read all two characters in each group on papers; (2) 'minimum character size for the least comfort', which was defined as the smallest font size among character sizes at which the participant reported that the characters caused comfort while reading; The '100%' was employed to determine the minimum character size associated with age groups in this study.

2.3 Apparatus

A room was constructed specifically for this study and the environment was comfortable for participants. Two light sources which can control the intensity of illumination were located on the ceiling of the room. To test the legibility of the characters for paper, the surface illumination level was 50 lx in this study.

Each participant was instructed to read 12 sets of characters (two-syllable Chinese characters) shown on papers at viewing distances of 50 cm and 80 cm. Unmeaningful words were employed for two-syllable Chinese characters in this study(Fig. 1 shows an example). Altogether, 12 character sizes, ranging in size from 4.5 pt to 18 pt, were tested in this study. The spatial complexity of the stimuli was also described by stroke frequency [8]. In this study, characters that contain 10 or more than 10 strokes were described as "complex" characters; and characters that contain 1 to 9 strokes as "simple" characters. Lanting is similar to Yahei, however, there are still difference between them.

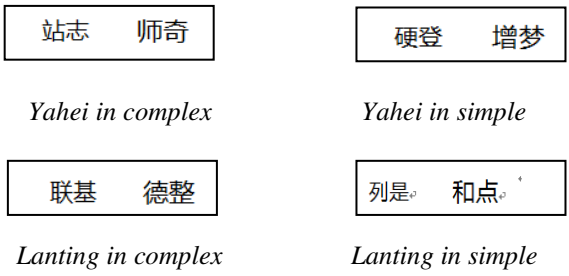

Fig. 1. An example of two-syllable Chinese characters

2.4 Experimental Design

The independent variables were age, viewing distance and font type. Levels for the independent variables are described in Table 1. Each participant performed 8 trials and all treatment combinations were performed in a random order.

This study investigated the effects of these independent variables on the following dependent variables. For measurement of the dependent variables: (1) 'minimum character size for 100% correctness'; (2) 'minimum character size for the least comfort'. To evaluate the effects of various independent variables [age (30s, 55s), viewing distance (50 cm, 80 cm), font type (Lanting in simple, Lanting in complex, Yahei in simple, Yahei in complex], on the two dependent variables, an ANOVA was employed.

Table 1. Description of the independent variables

Independent variables	Levels
Age	30s, 55s
Viewing distance	50 cm, 80 cm
Font type	Lanting in simple, Lanting in complex, Yahei in simple, Yahei in complex

3 Results

3.1 Analysis of Minimum Character Size for 100% Correctness

The effects of age and viewing distance on the minimum character size for 100% correctness were found to be statistically significant (all p-values < 0.05). There is no significant difference in font types.

In Figure 2, the 'minimum character size for 100% correctness' for people in their 30s was smaller (6.3 pt) compared to the people in their 55s (8.8 pt). Put more simply, young participants were able to correctly read character sizes smaller than those elderly participants with the same level of accuracy. The effect of viewing distance on the 'minimum character size for 100% correctness' was also evidently significant. Font sizes of 6.8 pt and 8.2 pt were reported as the 'minimum character sizes for 100% correctness' at a 50 cm viewing distance and at a 80 cm viewing distance, respectively. Though not significantly, the results of the 'minimum character size for 100% correctness' associated with the font type indicated that Yahei in simple (7.3 pt) and Yahei in complex (8.0 pt) allowed for smaller character sizes than Lantinghei in simple (7.6 pt) and Lantinghei in complex (8.4 pt) respectively.

3.2 Analysis of Subjective Minimum Character Size for the Least Comfort

Statistical analysis showed that age and viewing distance were significant factors for the 'minimum character size for the least comfort' (all p-values < 50.05). 'Minimum character size for the least comfort' means that the smallest font size among character sizes was such that a participant rated the character(s) as causing comfort while reading. There is no significant difference in font types.

Figure 3, showing the results of the main effects of 'minimum character size for the least comfort', indicates that the younger group described characters up to 8.8 pt in size as causing no discomfort to read, whereas the elderly group required a character size of at least 11.0 pt to read characters without discomfort. As expected, the effect of viewing

distance was significant. The 'minimum character sizes for the least comfort' were 9.3 pt and 11.5 pt for 50 cm and 80 cm viewing distances, respectively. Though not significantly, the 'minimum character sizes for the least comfort' associated with the font type indicated that Yahei in simple (9.5 pt) and Yahei in complex (9.9 pt) allowed for smaller character sizes than Lantinghei in simple (10.3 pt) and Lantinghei in complex (10.5 pt) respectively.

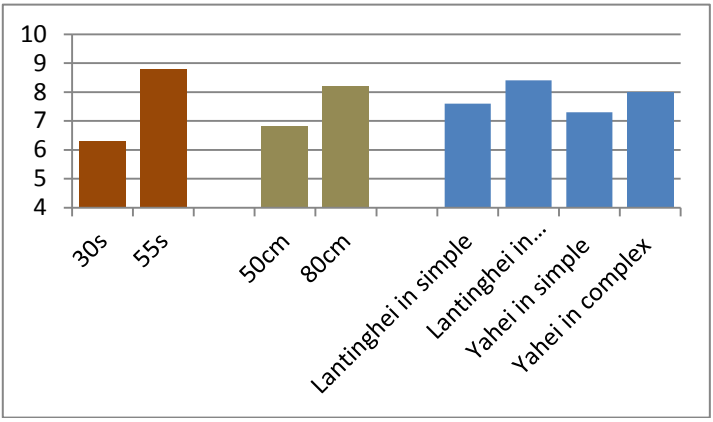

Fig. 2. The results of the main effects of 'minimum character size for 100% correctness'

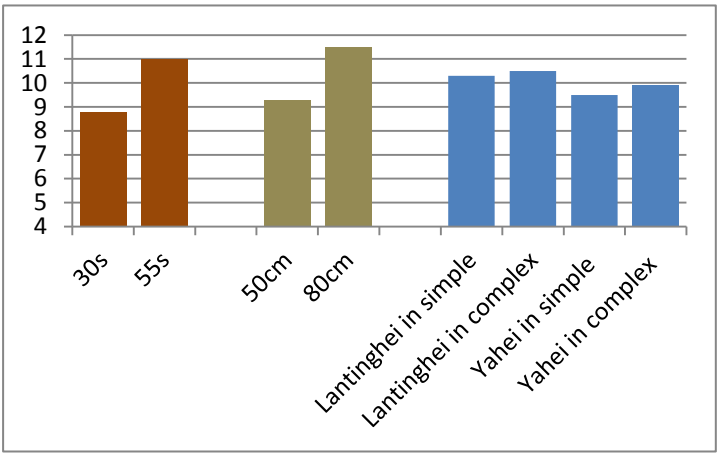

Fig. 3. The results of the main effects of' minimum character size for the least comfort'

4 Discussion

The present study investigated the effects of age, viewing distance and font type on two dependent variables: (1) 'minimum character size for 100% correctness'; (2) 'minimum character size for the least comfort'.

With regard to age, the young groups showed better legibility than elderly groups. The average character sizes for the two dependent variables of the group of subjects in their 55s were larger than those of the group of subjects in their 30s.That is, the average character sizes for subjects in their 55s were 6.3 pt and 8.8pt for the 'minimum character size for 100% correctness' and 'minimum character size for the least comfort', respectively, whereas those of subjects in their 30s were 8.8 pt and 11.0 pt, respectively. These findings might be explained by a reduction of light on the retina as well as the increasing of age.

According to the comparison analyses for correctness and comfort, the 'minimum character sizes for the least comfort' were larger than the 'minimum character sizes for 100% correctness'. This means that the character sizes that caused the least discomfort were significantly different from the character sizes at which people read with 100% correctness. Generally people preferred larger characters than the sizes at which people can nevertheless read with perfect accuracy. Therefore, performance as well as subjective preference should be considered when recommending character sizes for Chinese words to improve legibility, because even if the recommended character sizes ensure that they can be read correctly, people might still feel discomfort when reading.

5 Conclusions

This study examined the effects of age, viewing distance and font type on two dependent variables to evaluate the legibility of Chinese characters. A summary of the main findings is as follows:

Age: The young group (6.3 pt) could read character sizes smaller than those of the elderly group (8.8 pt) for the 'minimum character size for 100% correctness', respectively. In addition, the young group (8.8 pt) could read significantly smaller character sizes than those of the elderly group (11.0 pt) for the 'minimum character size for the least comfort', respectively.

Viewing distance: 50 cm (6.8 pt) allowed for character sizes about2pt smaller than those at 80 cm (8.2 pt) for the 'minimum character size for 100% correctness', respectively. In addition, 50 cm (9.3 pt) allowed for character sizes about 2pt smaller than those required at 80 cm (11.5 pt) for the 'minimum character size for the least comfort', respectively.

This study might be helpful in that they provide basic information with which to determine the legibility of Chinese characters.

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