Investigation of the Recognition of Different Font Sizes on Human-Machine Interface and Physiological Characteristics for Aged People

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Abstract With the growing population of the elderly people, designers of the human-machine interface must consider their psychophysiological characteristics. Three groups of subjects with a mean age of 21.0, 38.5 and 61.5 years, participated in the experiments. First they were examined by the perimeter. Then their near vision were measured by the Landolt ring test. Finally a Chinese character choosing task was done. The senile group had a marked decrease of light sensitivity and also a decline of near vision. For the 9-point font, there was no significant difference among three groups. However, for the 6-point font, the senile group reacted slowly. In the future, for the sake of the aged people, it would be of great importance to work out the critical and optimal font sizes under different light conditions. To obtain this goal, more experiments should be done and more subjects should be involved.

Keywords Font sizes recognition · Physiological characteristics · Human-Machine interface design

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1 Introduction

The human-machine interface design is important in modern machine. The study of it is widely used in areas of cell phone, computer, tablet PC and other intelligent electronic products. Many factors in the human-machine interface design seriously affect the quality of user experiences, and one of the factors is font size.

Aging is the time-dependent accumulation of cellular insults or damage accompanied by subsequent functional decline that increases organisms' vulnerability to death [1]. Advanced age is widely recognized as one of the biggest risk factors for many of the leading causes of vision loss, such as Presbyopia, cataract, glaucoma, age-related macular degeneration (AMD) and diabetic retinopathy [1, 2]. One of reasons why the advanced age influence the vision is that the level of some endocrine substances produce changes in the eyes. According to recent studies, melanopsin, melatonin rhythms, and many other endocrine substances are responsible for the human vision [3, 4], and some of these substances would decrease or change when human is getting old. Not only the endocrine substances, but also some functional cells change in the development of human's life. And the human anatomy theory explains the sensitivities of human's eyes depend on the rod cells and cone cells in the eye. Rod cells produce rhodopsin to make human's retina sensitive to the weak light and therefore it matters to eyes function such as dark adaption. Moreover, many other factors can also influence the synthesis of rhodopsin, for example, the lack of vitamin A assimilated from outside. As people are getting old, the synthesis function of their body's cells, including rod cells and cone cells, will decay. This change is one of the reasons causing weakness of the older man's sensitivity to light.

Some researches prove that the aged people have different performances in the function of eyes. Raymond P. Najjar discusses age-related decrease in non-visual sensitivity to light. The age has a great relationship with human's non-visual sensitivity [5], which relates to one of the intrinsically-photosensitive retinal ganglion cells [6]. And the human's visual sensitivity also relates to another intrinsically-photosensitive retinal ganglion cells, namely roll cells and cone cells. Joanne M. Wood and his team [7] discover that different aged drivers also had different visual abilities of seeing pedestrians at night. It proves that some skills of human's eyes become weaker when human is getting old.

The physiological characteristics of human's eyes are meaningful in the human-machine interface design. Different font sizes influence the information transmission efficiency [8]. Andrew R. Whatham and his partners carry out a series of experiments in which subjects with normal vision are asked to read isolated lowercase single letters and lowercase words of 4, 7 and 10 letters, in separate tests. And the result reveals that critical character sizes have a functional relation with the subjects' acuity, which proves the font size is able to be the measurement of human's vision [9]. The surrounding luminance also makes the difference in the recognition of the word which prove that the light intensity is one of the important factors in the font recognition [10]. The human characteristics which relates to the

light intensity is their sensitivity to light. Thus, we make a hypothesis that the sensitivity to light influence the human's performance on the human-machine interface; ultimately, vision and sensitivity to light may influence the design of font sizes on the human-machine interface.

Based on the abovementioned studies, the hypothesis of this study is that human's age, vision acuity and sensitivity to light affect the ability of recognition of different font sizes on human-machine interface. And its aim is to discover the relations among them, hoping to provide a reference for the human-machine interface design. In this study, three experiments are designed to measure the physiological characteristics of subjects' eyes. The first experiment measures the subjects' sensitivity to light using IVS-201B automatic perimeter. The second experiment applies an E-prime program to record the reaction time of recognizing the different font sized Chinese characters. And the third is the Landolt ring experiment to measure the subjects' near vision. The statistical analysis will be used to find out the relations.

2 Methods

2.1 Subjects

Eighteen subjects participated in the project (N = 18). They were divided into three groups by age, and each group consisted of three males and three females. The average age of each group was 21.0 ± 2.0, 38.5 ± 5.5 and 61.5 ± 5.5, respectively.

2.2 Experimental Procedures

Apparatus.

(1) IVS-201B Automatic perimeter: the subject was required to cover one eye with an eye patch and receive the check of the perimeter to measure Central 30° field of vision. The measured results were represented by numbers (refer to Fig. 1), and the larger the number is, the more sensitive to light.
(2) Lenovo X201 computer: for running E-prime programs.

E-prime Programs. Two E-prime programs were used in the experiment. The subjects finished the tests under the environment with indoors illumination rated at 300 lx.

One of the programs was aimed to identify the ability of recognizing the different font sizes on the human-computer interaction interface. The program asked the subjects to choose two Chinese characters on the same page. The displayed page

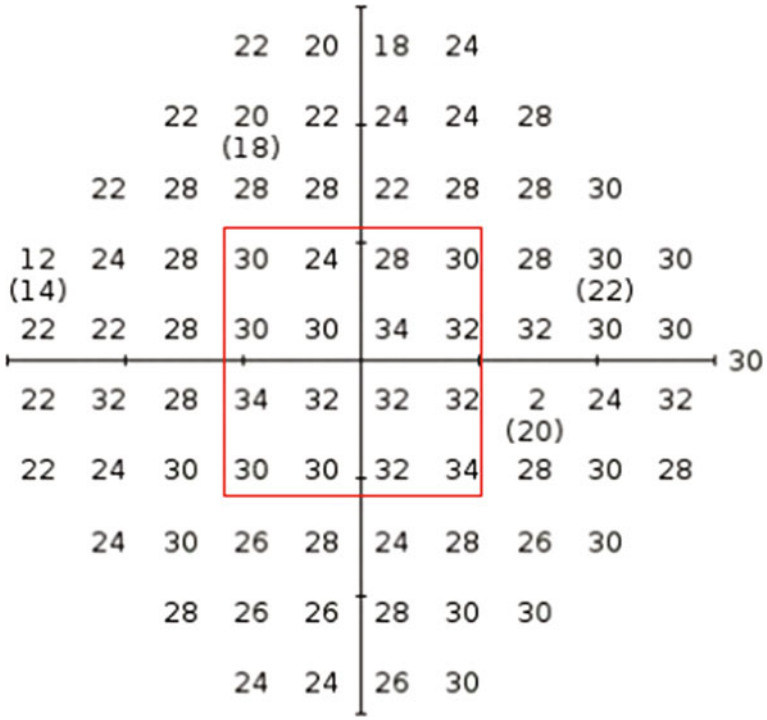

Fig. 1 Digitized sensitivity to light

had nine optional rectangles and each contained two characters inside except the middle one. The subjects were supposed to choose the middle character first and then identify the same character from the surrounding rectangles. Both the reaction time (RT) and accuracy were recorded by E-Prime (Fig. 2).

Another program was meant to check the subjects' near vision. It used Landolt ring to serve the purpose. Subjects were asked to sit about forty centimeters away from the laptop's screen and look at the screen horizontally. When the Landolt ring appear in the center, they were required to choose the right direction of the gap on the Landolt ring by pressing four buttons 'w, a, s, d', which represented four different directions. There were 29 levels of Landolt ring sizes with visual angles ranging from 1 to 15 arc minutes. E-prime recorded reaction time (RT) and accuracy of each trial correctly (Fig. 3).

2.3 Statistical Methods

(1) First, this study listed the averaged value and standard deviation of each group to give a clear description;

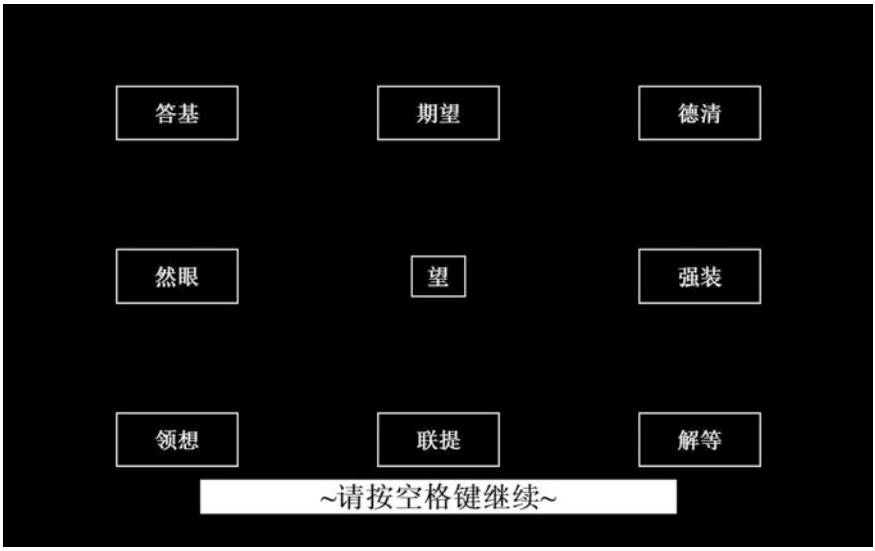

Fig. 2 The interactive interface that measured the reaction time

Fig. 3 The interface of the program that tested the vision

(2) Second, two-tailed paired t-test was used to get the *H*-value and *P*-value. T test is the most frequently used test to determine if two sets of data are significantly different from each other.
(3) Lastly, linear correlation analysis was used to judge the linear correlation among factors and get the correlation coefficient (R) and *P*-value.

3 Results

The 4 × 4 centering matrix (shown in Fig. 1) was chosen to represent each subject's sensitivity to light. The reason why these data has been chosen was that the subjects mostly had the best feeling to light in this area and normal people used this

part of their eyes to watch things for most of the time. This area of human's eyes has a great influence on human's life and its value is meaningful in statistics.

The vision of each subject was represented by the lowest level of Landolt ring size that he was able to recognize. The ability of subjects to recognize the font size on computer was measured by the reaction time on recognizing 6 font size and 9 font size. In analyzing this outcome, the recognition accuracy was ignored because the two font sizes were large enough for subjects to do almost every trial correctly.

3.1 Averaged Value and Standard Deviation Analysis

According to the averaged analysis (see Table 1), the sensitivity to light and vision decreased along with the increase of age especially between the senile group and the middle aged group. It might be due to the degeneration of subject's eyes as they are getting old. Reaction time of 6-point character choosing task also increased along with the increase of age.

3.2 T-Test Result Analysis

T test result revealed that the sensitivity to light had significant difference between middle aged and senile group, the same can be said of the difference between youngest and senile group, especially in the left eyes' data. The other factors did not reveal the obvious regulation in the comparison (Table 2).

Table 1 Averaged values and standard deviation of each group

Group	Youngest	Middle aged	Senile
Age	21.67 ± 1.47(yrs)	39.00 ± 4.24(yrs)	60.83 ± 4.07(yrs)
Sensitivity to light (OS)	31.73 ± 0.72	31.75 ± 1.17	25.13 ± 5.06
Sensitivity to light (OD)	31.83 ± 1.55	31.92 ± 1.13	25.10 ± 4.67
vision	2.17 ± 2.40 (level)	3.17 ± 2.56 (level)	5.17 ± 2.71 (level)
RT(6)	3127.84 ± 961.97 (ms)	3486.27 ± 570.19 (ms)	3907.95 ± 1232.53 (ms)
RT(9)	2517.25 ± 564.19 (ms)	2477.64 ± 308.21 (ms)	2787.25 ± 532.72 (ms)

(*OS* means the left eyes, *OD* means the right eyes)

Table 2 *P*-values from t-test among groups

Group	Youngest and middle aged	Middle aged and senile	Youngest and senile
Sensitivity to light (OS)	0.323090	0.032024	0.026538
Sensitivity to light (OD)	0.919726	0.241816	0.189437
vision	0.580456	0.269875	0.095162
RT(6)	0.345665	0.541139	0.160116
RT(9)	0.818502	0.354997	0.568550

3.3 Correlation Analysis of Factors

Age and Sensitivity to Light. The correlation analysis revealed the regulation between age and averaged sensitivity to light. The *P*-value is 0.054 and the correlation coefficient (R) that is −0.5395 which prove that the sensitivity to light has negative correlation with age. This result stated that the age may influences the human's sensitivities to light.

Age and Reaction Time. The results did not reveal that age is one of the influencing factors of the reaction time in recognizing the characters. The correlation *P*-values were 0.165 (6-point font), 0.283 (9-point font) and the correlation coefficients (R) were 0.341 (6-point font), 0.267 (9-point font). The explanation of this phenomenon could be due to the fact that the font size was not small enough.

Vision and Reaction Time. The results did not indicate that vision was the influencing factor of the reaction time, either. The correlation return *P*-values were 0.398 (6-point font), 0.201 (9-point font) and the correlation coefficients (R) were 0.212 (6-point font), 0.316 (9-point font). The reason may be that the font sizes were large enough for the subjects to see them clearly despite the differences in their vision.

Sensitivities to Light and Vision. The linear correlation was not obvious between averaged sensitivity to light and vision. *P*-value was 0.1025 and the correlation coefficient (R) was −0.432. The relation may exist between them but need further researches to testify.

Sensitivities to Light and Reaction Time. Averaged sensitivity to light had significant relation to their reaction time for 9-point characters. The correlation return *P*-values were 0.545 (6-point font), 0.016 (9-point font) and the correlation coefficients (R) were −0.153 (6-point font), −0.560 (9-point font). Special attention should be paid to this relation in future studies.

4 Conclusion

The results suggest although senile group seem to have disadvantages in sensitivity to light, vision and reaction time, t-test and linear correlation prove that age only has significant negative correlations with sensitivity to light. When designing the luminance of human-machine interface, the relation between the sensitivity to light and age should be taken into consideration. However, another relation between the sensitivity to light and reaction time of the recognizing experiments shows significance for the larger characters (9-point font size). The reason of this phenomenon may be that the experiments have controlled the indoors illumination rated at 300 lx. In this condition, the difference among the individuals' sensitivities to light are not revealed by the recognizing experiments. In the further research, the indoor illumination condition should be changed to find out the relation between these two factors and number of subjects should be increased.

The vision test reveals that the senile group have a certain gap with the youngest and the middle aged one. However, the difference is not big enough to justify the relation between the age and the vision. The relations of vision, sensitivity to light, and the reaction time are not revealed by the experiment. The probable reasons could be that the font sizes in the experiment is not small enough to reveal the difference in the subjects' vision.

This study discusses the sensitivity to light, reaction time on recognizing experiments, age and vision, but there exist some limitations:

(1) The quantity of the subjects is too small. In the future research, the quantity of the samples should be increased;
(2) Except the factors that these experiments included, there are also some other factors having a great impact on the font recognition which need considering in the future research;

To conclude, In the future, for the sake of the aged people, it would be of great importance to work out the critical and optimal font sizes under different light conditions. To obtain this goal, more experiments should be done and more subjects should be involved.

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