LEGIBILITY OF CHARACTERS ON MOBILE PHONE DISPLAYS

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Abstract. Mobile phones are very popular around the world today, and the use of text email with short message service (SMS) is spreading. In this study we evaluated the legibility of characters on the liquid crystal displays of mobile phones. The subjects were 75 persons aged from 19 to 80 years (42.5 ± 18.2 years). When characters are small, younger people assure readability by shortening the viewing distance. Conversely, elderly people find it far more difficult to see and read small characters.

1. Introduction

In December 2007, the number of mobile phone users was more than 100 million in Japan, and more than 2 billion worldwide. The use of text email with short message service (SMS) is becoming more widespread, and the number of occasions on which text information is handled through Web access from mobile phones is increasing.

Mobile phones are often the information terminal that is nearest to us in our daily lives, and today they are used to distribute text information including disaster information (Hasegawa et al., 2005) and living information. Mobile phones are widespread and commonly available, and should be easy to use for everyone, including the elderly (Hasegawa et al., 2006). In this study we evaluated the legibility of characters on the liquid crystal displays of mobile phones, using an original method that was modified for mobile phones in conformity with the methods of ISO standards (ISO 9241-3. Amendment 1, 2000). The age of the subjects in the experiment ranged from 19 to 80 years.

2. Methods

A method to evaluate flat panel displays is provided in ISO 9241-3, Amendment 1 (2000). We have modified it for mobile phones and used for the purpose of investigating the legibility of characters displayed on mobile phones. Subjects search meaningless alphanumeric text (Figure 1) for target characters. Since the number of characters that can be displayed on a single small mobile phone screen is limited, readability has been measured without fixing the viewing distance (distance from eyes to display).

We used a mobile phone with a 240 × 320 dot liquid crystal display (Figure. 2; Panasonic P903iX), on which the measured luminance was 116.0 ± 2.1 cd/m^2, and the contrast ratio was 19.3. Three different sizes of text were used (3 heights for single characters, L: 2.5 mm, M: 2.0 mm, S: 1.0 mm. The width of the characters was 1/2 the height in all cases). The displayed text was meaningless, and with all character sizes the screen contained 200 characters: 20 characters/line × 10 lines. The text included 4, 5, or 6 target characters (the capital letter “A”). The subjects searched for "A" by following the character strings horizontally as if reading. They gave an oral indication each time they found a target character and when they were finished searching. In each experiment we measured the number of target characters detected, the time required for the search, the viewing distance, and recorded the participants’ subjective evaluation of legibility, from 1 (difficult to read) to 9 (easy to read).

The subjects (Japanese) were 75 men and women aged from 19 to 80 years (42.5 ± 18.2 years), including 37 people aged 19-39 years (young group), 19 aged 40-59 years (middle-aged group), and 19 aged 60-80 years (elderly group). Subjects who normally wore glasses when reading a newspaper participated in the experiment wearing glasses as usual.

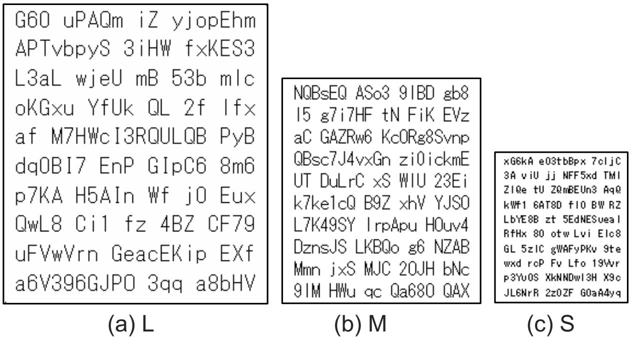


Figure 1. Examples of meaningless text used in the experiment.

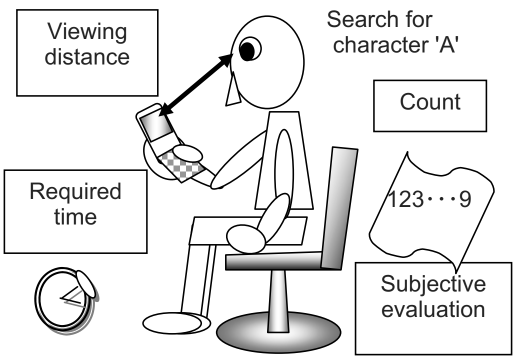


Figure 2. Experimental setup and measured items.

3. Results

Age dependency of (a) viewing distance, (b) search speed = 200 (characters) / required time (sec), and (c) error rate = | Nc - Nt | / Nt × 100 (%), where Nc is count and Nt is number of target characters, are shown in Figure 3. Experimental results for each age group for (a) subjective evaluation, (b) viewing distance, (c) search speed, and (d) error rate are shown in Figure 4.

A comparison of character size for all subjects (Figure 4 (a)-(d)) revealed that: (a) there was a significant decrease in the subjective evaluation with character size, in the order L > M > S, (b) viewing distance became shorter with character size S, (c) there was no significant difference in search speed with character size, and (d) the error rate was significantly higher with character size S than with the other sizes.

In age dependency (Figure 3) and the comparison between the age groups ("young," "middle-aged," "elderly," in Figure 4 (a)-(d)) it was found that the elderly subjects had significantly lower subjective evaluation and search speed than the other groups. Meanwhile, the young group had significantly shorter viewing distance and lower error rate.

(a)

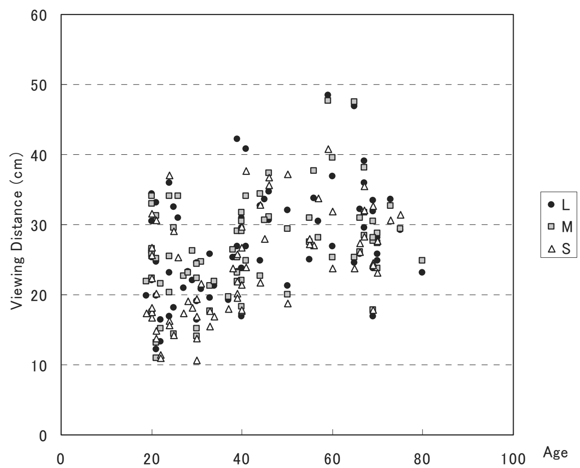


Figure 3. Age dependency of results. *Figure (b) and (c) are shown on the next page.*

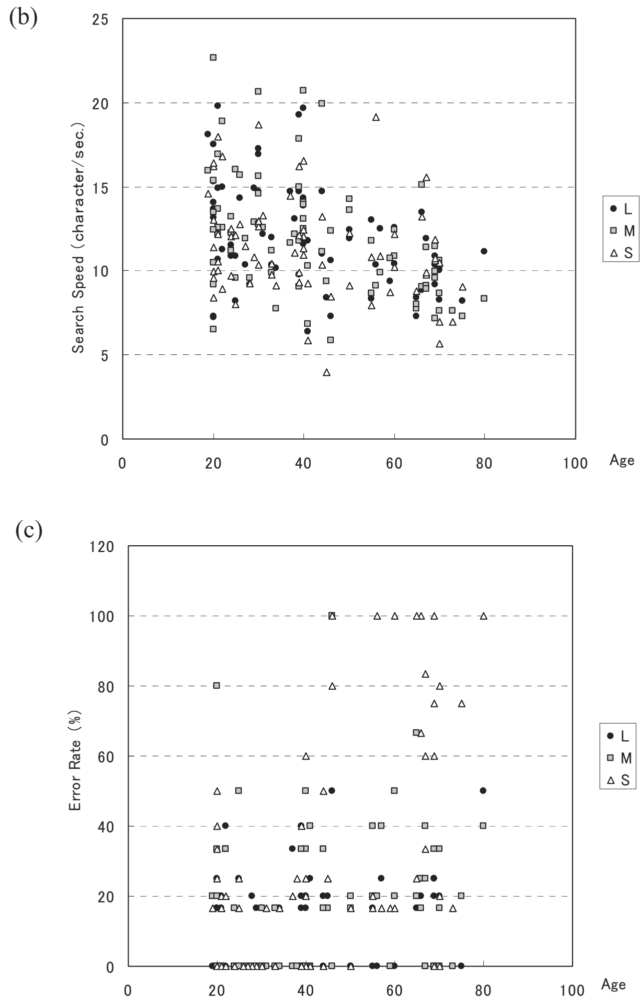
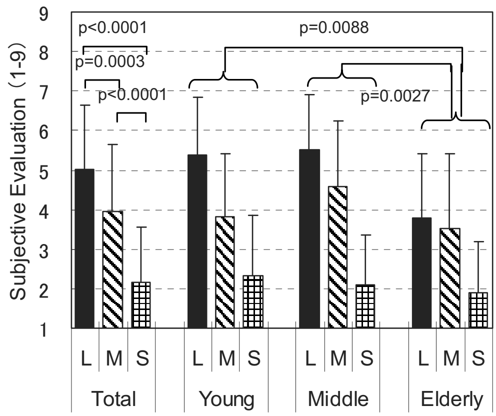


Figure 4. Age dependency of results.

(a)



(b)

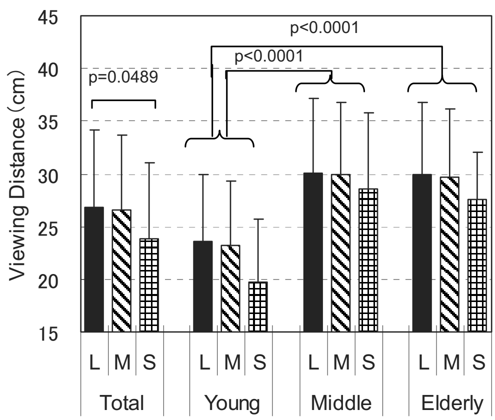


Figure 5. Results for each age group; young: 19–39 years, middle-aged: 40–59 years, and elderly: 60–80 years. Figure (c) and (d) are shown on the next page.

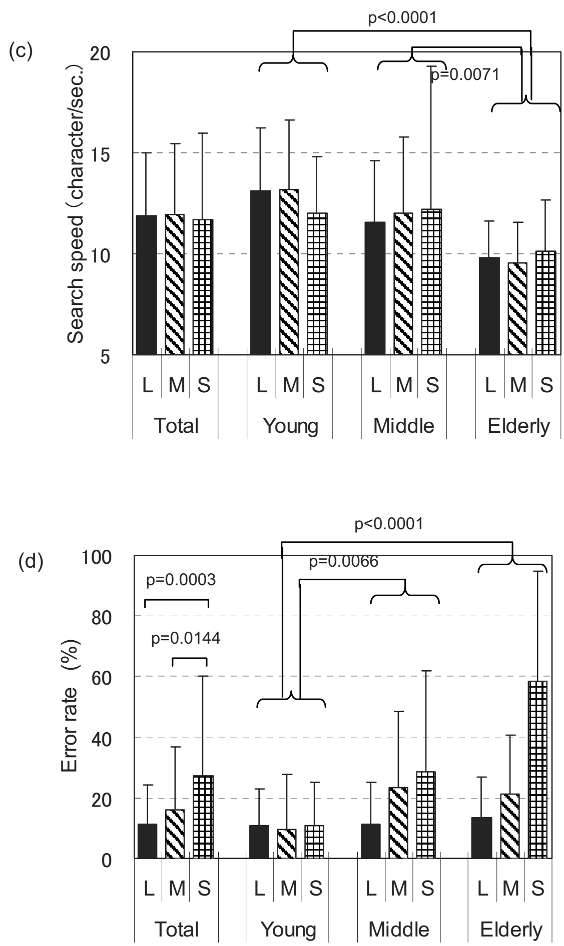


Figure 6. Results for each age group; young: 19–39 years, middle-aged: 40–59 years, and elderly: 60–80 years.

4. Discussion

As VDT work criteria, the ISO 9241-3 (1992) recommends that the minimum alpha-numerical character height should be 16 minutes of arc, with character heights of 20 to 22 minutes of arc preferred. The visual angle of 20-22 minutes of arc corresponds to an assumed character height of 1.9 mm (M size in this experiment) at a viewing distance of 30 cm.

The decrease in legibility due to a decrease in the character size was objectively reflected by an increased error rate in the aged group. In the young group, viewing distance decreased with a decrease in the character size. This may have the effect of making the visual angle larger, thereby increasing the size of the displayed small characters on the retina for the maintenance of legibility.

Viewing distance increased with the age of the subjects due to the influence of presbyopia (Hasegawa et al., 2006, Omori et al., 2002). The aged may have difficulty in adjusting viewing distance to optimal viewing distance, at least in the range allowing adjustment by the length of their arm with a mobile phone in their hand.

5. Conclusion

When characters are small, younger people assure readability by shortening the viewing distance. Conversely, elderly people find it far more difficult to read small characters at any distance. Universal design that considers the abilities of older people is desirable.

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