RELATIVE LEGIBILITY STUDY USING CHINESE OPTOTYPES

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ABSTRACT

Traditionally, visual acuity test charts have been constructed using the English alphabet. It is desirable to have charts made in the native language of the Chinese and Asian populations. Previous efforts in this respect have not considered the relative legibility of Chinese optotypes. In this study, twelve Chinese optotypes were constructed according to the Snellen principle and subjected to a relative legibility trial. This study provides a basis on which Chinese optotypes of near-equal legibility may be selected.

Keywords: Visual acuity test, visual acuity charts, Chinese optotypes, legibility.

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INTRODUCTION

The visual acuity chart is one of the basic instruments for a vision examination. At present, the majority of the available visual acuity charts are composed of the English alphabet. For Asians who do not know English, visual acuity assessments are usually carried out using illiterate 'E' or Landolt 'C' charts. These charts are less reliable than letter charts because there is a one-in-four chance of guessing the correct answer.

As visual acuity tests should relate to daily tasks, it is desirable to assess visual acuity using letters or characters that are familiar to the observer. There are many different cultures in Asia and it is not possible to find a language common to every Asian. However, it is possible to choose a language that is recognized by a larger number of Asians. Chinese characters are most suitable for this purpose as they are recognized by the Chinese, Japanese and Koreans, which together represent a substantial portion of the Asian population.

Previously, a Chinese distance visual acuity chart (Woo & Lo, 1980)[1] and a set of Chinese near vision cards (Johnston, 1985)[2] have been designed. The former used simple Chinese characters which conform to the Snellen principle (Fig 1) while the latter used a mixture of simple and complicated Chinese characters. Both designs adopted the LogMAR principle in the progression of optotype size[3].

The Chinese characters chosen by Woo & Lo have apparent differences in their legibility because some characters have a greater proportion of blackness compared to others and are more likely to be affected by blur (Fig 2). The characters employed by Johnston on the reading cards range from very simple to very complicated (Fig 3). Johnston's decision to use a mixture of simple and complex characters was a deliberate one, in order to exactly simulate the reading task[2]. Hence these reading cards are better described as a recognition test rather than a visual acuity test.

The importance of adopting optotypes of near-equal legibility in a visual acuity chart is well recognized[4-6]. An optimal visual acuity chart, made of Chinese characters and based on the Snellen principle, has yet to be designed. One of the major tasks in this regard is choosing and constructing optotypes that yield near-equal legibility. It is the purpose of this study to design such optotypes and to carry out a relative legibility trial.

METHOD

1. Selection and Construction of Optotypes

Characters chosen must be simple enough to conform to the Snellen principle. This is difficult because, unlike the English alphabet, most Chinese characters are complicated and there are very few simple ones. Nevertheless, twelve characters were identified that may be constructed to conform to the Snellen principle (Fig 4). These characters are also simple enough to be readily understood by all Chinese, irrespective of their level of education.

The chosen characters were drawn in a 5 x 5 format on a white background. All these Chinese optotypes were intended for use in the development of a visual acuity chart, contour interaction bars were incorporated to simulate the crowding phenomenon or separation difficulty effect that has been noted by previous investigators[7-9], who reported that symbols presented in a group were harder to recognize than those presented individually. The contour interaction bars subtend a visual angle of 1 minute of arc and were placed 5 minutes of arc away from the optotype[10] (Fig 5). Landolt 'C' in 8 orientations were also constructed in a similar fashion (Fig 6). Each resultant optotype was photographed and made into positive projection slides (black optotypes on white background) in 5 sizes which followed the LogMAR progression. When projected at 3 metres, these optotypes corresponded to visual acuities of 6/12, 6/9.5, 6/7.5, 6/6 and 6/4.8 respectively.

2. Selection of Subjects

Thirteen subjects (6 male, 7 female) were recruited for this study. All had normal ocular health and monocular habitual visual acuity of better than or equal to 6/9. These subjects were bilingual in Chinese and English and aged between 18 and 25.

3. Procedure

Monocular habitual visual acuity (visual acuity threshold) of the right eye of each subject was established using Landolt 'C' presented on a matt white background at 3 metres using slide projector. Visual acuity tests were carried out in a dim room, chart luminance was measured to be 600 $\pm$ 25 cd/m^2. The luminance contrast of the test types and the background was

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Fig 1. – The Snellen Principle

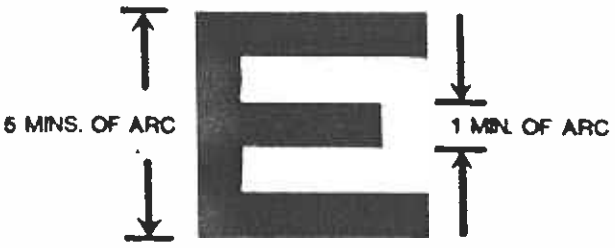

Fig 2. – Sample of Chinese Optotypes Adopted by Woo & Lo, 1980(1)

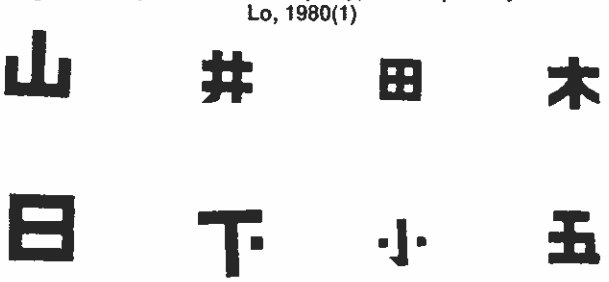

Fig 3. – Sample of Chinese Optotypes Adopted by Johnston, 1985(2)

greater than 90%. Chinese optotypes near the visual acuity threshold of the subject, as determined using Landolt 'C', were then presented to the right eye in the same manner. Subjects were encouraged to recognize the optotypes but were not forced to make a response. Each optotype appeared 4 times in random sequence, 4 Landolt 'C' were also randomly mixed in with the Chinese optotypes, hence each subject was presented with 52 test types.

4. Scoring and Analysis of Results

The responses to optotype presentations were recorded as 'correct' or 'incorrect'. For each optotype, the total number of correct responses given by all subjects was used in the calculation of a 'Percentage Correct Score' (PCS) as follows:

$$PCS = \frac{\text{Total No. of correct responses}}{\text{Total No. of presentations (52)}} \times 100\%$$

The mean and standard deviation of the PCS were calculated for the Chinese optotypes, both individually and overall. Similar analysis was done separately on the results of the Landolt 'C'.

RESULTS

The Percentage Correct Scores (PCS) and Standard Deviations (SD) of the Chinese optotypes, both individual and overall, are shown in Table I. Legibility trial results of Landolt 'C' are shown in Table II.

Fig 4. – Chinese Optotypes Used in Present Study

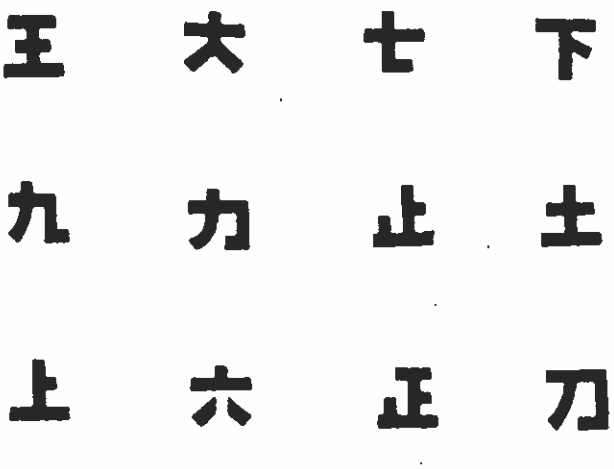

Fig 5. – Chinese Optotype with Contour Interaction Bars

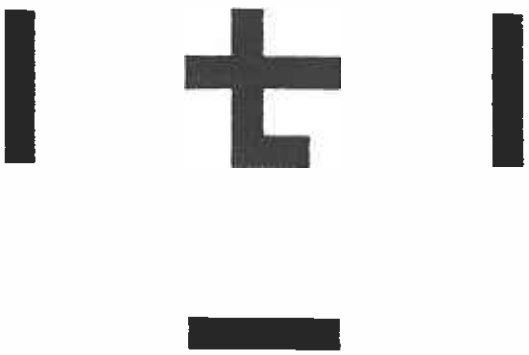

Fig 6. – Landolt 'C' with Contour Interaction Bars

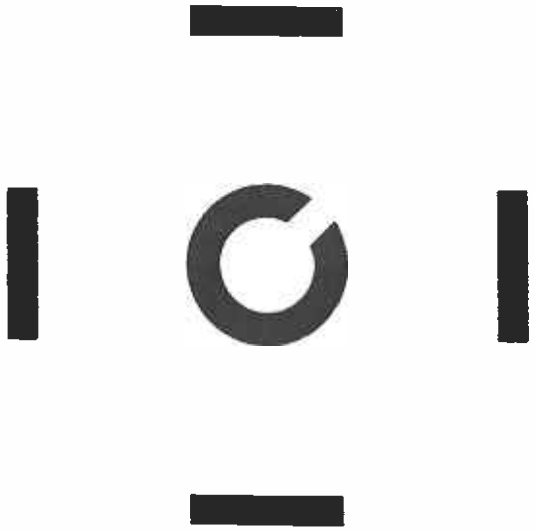

Table I
Relative Legibility Trial Results of Chinese Optotypes

TEST TYPE	下	九	上	七	六	王	力	刀	土	止	大	正
PCS (%)	98	92	91	86	77	74	73	69	60	56	38	31
SD	7	29	12	24	33	35	36	29	46	38	43.	39

Mean PCS of Chinese optotypes = 70.4%
Standard deviation = 21.06

Table II
Relative Legibility Trial Results of Landolt 'C'

TEST TYPE	Landolt 'C'
PCS (%)	82
SD	28

DISCUSSION

It can be seen that Landolt 'C' is more legible than most of the Chinese optotypes used in this study. Recognition of Chinese characters is a harder task because they are more complicated and there is a greater choice compared with Landolt 'C'.

To select Chinese optotypes for the construction of visual acuity charts, the findings of this study are compared to the relative difficulty scores of Sloan letters[5]. Such a comparison is desirable to develop a Chinese visual acuity chart which gives similar results to existing letter charts.

Sloan letters have an average relative difficulty score of 82% with a deviation from average of about ± 12%[5]. The average legibility of these letters has been shown to be equal to the difficulty in visual resolution of the Landolt 'C'[4,5].

The fact that the percentage correct score of the Landolt 'C' obtained in this study equals the average relative difficulty score of the Sloan letters suggests that the nature of the visual task presented in this study is similar to that used by Sloan. Hence it would seem reasonable to compare results from the two studies.

If the range of legibility of Sloan letters is adopted (ie. 70 to 94%) to form a basis for the selection of Chinese optotypes from the present study, this would suggest that 7 characters, from '刀' (PCS 69%) to '九' (PCS 92%) are suitable for use in the construction of distance and near visual acuity charts.

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