A CHINESE WORD ACUITY CHART WITH NEW DESIGN PRINCIPLES

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SYNOPSIS

A new visual acuity chart with Chinese characters on a logarithmic progression scale has been constructed. The rationale for its design and the method of using this chart are described. It is compared with the popular illiterate E chart used in China. The adoption of a logarithmic progression of character sizes makes it possible to accurately designate a visual acuity score using various standard and non-standard testing distances. Contour interaction is taken into account in the design of the chart.

Since Chinese is read from top to bottom and from right to left. Chinese patients may find one of the two versions easier to read as the characters on that chart are placed in vertical columns with increase in character size from right to left. An astigmatic dial and a target for the cross cylinder check test are also included.

In the western world, visual acuities are generally given in English or metric Snellen notations, angular subtenses, percentages and decimals.[1] In China, visual acuities are usually assessed by means of the Illiterate E chart in decimal acuities. Two popular acuity charts used in the Orient are mentioned in a recent text on physiological optics.[2] One incorporates the Landolt C and some Japanese symbols whereas the other uses English letters.

A new Chinese word acuity chart is described in this study. It is the first chart made up of calibrated Chinese characters. Two versions of the chart have been designed, one to be read horizontally and the other vertically. Only the chart to be read vertically is described in this paper.

Sloan[3] stated that the ideal test object in visual acuity charts should contain horizontal, oblique, vertical and curved contours, so that it is recognized only when all meridians are focused clearly. The illiterate E chart used throughout China lacks both oblique and curved contours. As a result, uncorrected astigmatism especially in the oblique meridians may lead to an inaccurate visual acuity score. Since there are only four possible orientations in the illiterate E chart, there is a possibility of guessing.[4] The recognition of figures of varying complexity, but of equal size, is a test of form vision[5] while the detection of the gap in a Landolt ring test may well be a test of light sense rather than of form sense as the gap could be detected by its increased illumination before its form is clearly recognized.[6] Furthermore, in the procedure using an illiterate E chart, the patient is only required to tell the examiner the direction of its open end. It is thus

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similar to the testing situation with Landolt rings. Occasionally, the patient may be confused as to the directions of right and left, adding further possible errors and inconvenience in the assessment.

Recognition of characters or words requires more of the patient than does an E chart. This kind of acuity may also be different from distance letter acuity because word acuities are determined with the use of Chinese characters since the Chinese language has no alphabet although individual characters may have as few component as English letters do. Word acuity and letter acuity may be quite different.[7] Lovie[8] stated that the most complex rows of letters at distance gave the closest prediction of reading or words acuity. Simple characters in a complex row design have been selected for this chart, (Figures 1 and 2) to provide optimal legibility, to conform to the universal Snellen design and to be suitable for the majority of Chinese living in China and overseas.

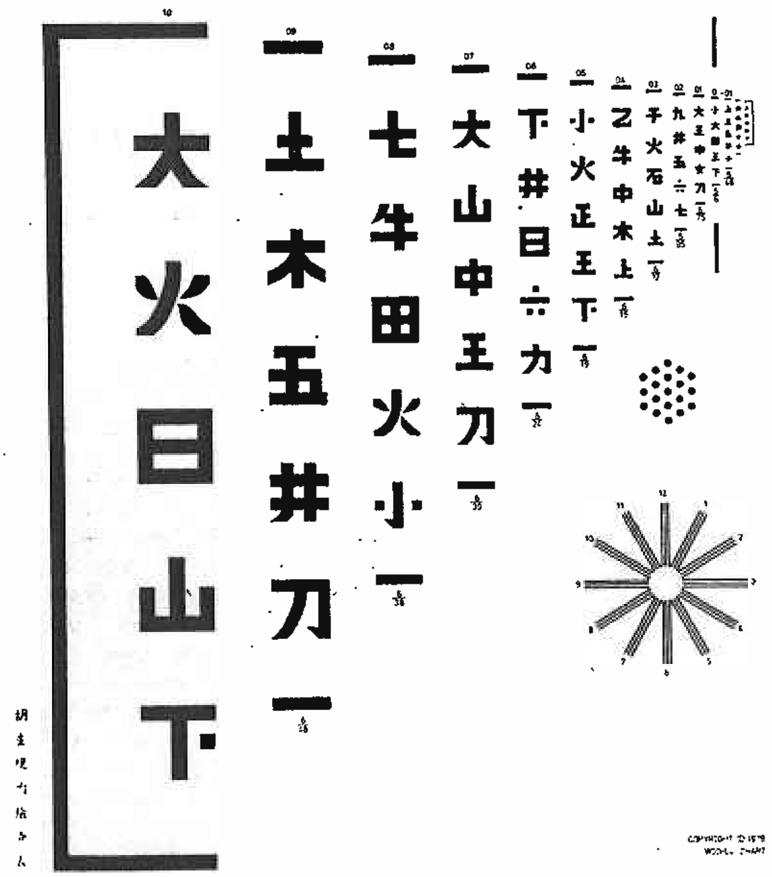

Figure 1. Reduced photograph of the distance word acuity chart to be read from top to bottom and right to left.

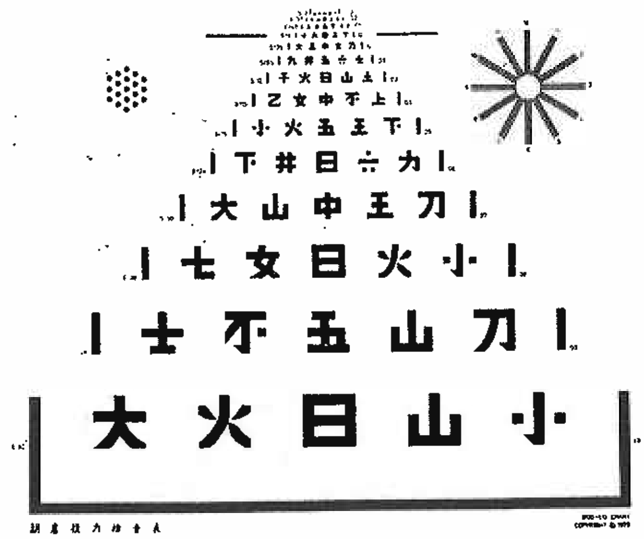

Figure 2. Reduced photograph of the distance word acuity chart to be read from left to right and top to bottom.

One of the factors in testing visual acuity is the preceptibility of the letters. Investigators[9,10,11] have categorized the relative difficulty of English letters in their recognizability. A major factor is the letter's degree of resemblence to the Snellen letter. This degree in turn may be related to the number of strokes, and the proportion of blackness inside the test letter. To achieve consistency, the order of the characters in their number of strokes is the same in each column in the chart. Although the characters differ in the number of serifs present, it has been shown that the difference in acuity of letters with and without serifs is not statistically significant thus not likely to be of importance for clinical use[12,13]. Each character has a 5x5 format: its height equal to 5 stroke widths. As a result, each character subtends an angle five times that of the stroke which indicates the patient's angular resolution.

Description of the Chart:

The characters on the chart are read from top to bottom and from right to left since most Chinese literature has this format and is thus more familiar to the patient. The chart begins with the smallest character column first (i.e. at the right) rather than with the largest one as in conventional charts. This feature in our view saves some time in administering the test. With a conventional chart, the patient often unnecessarily spends time reading the whole chart before finally reaching the smallest row of letters or the maximum visual acuity line. With this new design, the patient can quickly skip the first one or two rows when they are too small to read and go directly to the smallest one he can read in a shorter span of time. This feature also reduces the possibility of getting familiar with the characters as in the case with starting from the largest characters first. For the examiner who wishes his patients to start with the largest ones first, he can instruct the patient to read from left to right instead.

Current charts in China use the decimal system for the progression of letter sizes. One of the objections to this system is that a given decimal often tends to be interpreted as if it indicated a percentage of normal vision. This implication is quite untrue and is often dangerously misleading.[14] Conversion or interpolation to other visual acuity scales may be confusing unless tables are consulted. When nonstandard testing distances are used, correction factors can be cumbersome and inaccurate.

A geometric progression in uniform steps on a logarithmic scale is therefore adopted in this chart. Such a design was first proposed by Snellen in 1897 and was subsequently recommended by Green[15] and Snell[16]. It has been accepted by the International Council of Opthalmology Committee on Optotypes and by Germany in its new German Standards for the measurement of visual acuity. The ratio of this geometric progression has been established as $\sqrt[3]{2}$ or $\sqrt[10]{10}$, which is equal to 0.1 log unit or 1/26[3,8,15]. With this logarithmic progression in size change, accurate visual acuity scores can be obtained readily at various nonstandard testing distances. The selected distance may be greater or less than the standard 6m distance, as long as it is chosen in the same geometric progression. Examples of these distances are 6, 4.8, 3.8, 3.0 meters. They are conveniently labelled on the chart as the denominator of the letter size sequence in Snellen notation. Reduction of the distance by each step causes an increase in the angular size of the characters by an amount corresponding to 0.1 log unit, thus creating a one-column shift and requiring a correction factor of 0.1.[3,8,17].

For example, consider a case where the testing distance is changed to 4.8 m from the standard 6m and the patient's best VA score at 4.8 m is 0.2 logMAR or 6/9.5 (20/32). Since there is a shift of 0.1 log unit from the change in distance, the corrected score should be 0.2 + 0.1 = 0.3 logMAR or 6/12 (20/40) Similarly, changing to a testing distance of 3.0m will require a correction factor of 0.3 units. When the distance is increased from 6m., the direction of change is opposite hence requiring a negative correction factor. This correction scheme, however, is straightforward: shortening the distance means an increase in visual angle hence an increase in logMAR score. After this conversion, the corresponding Snellen score can be obtained by simply reading it from the chart. The Minimum Angle of Resolution is the reciprocal of the Snellen score or the anti-log of the corrected logMAR score.

Although the chart is designed for a standard testing distance of 6 m., with characters ranging from -0.3 to 1.0 in logMAR units in 0.1 log intervals, the range of their relative sizes can easily be extended by lengthening or shortening the testing distance. This is particularly useful in testing the low vision patient who may not be adequately tested with the conventional chart that has inconsistencies in number of letters, progression of letter sizes and contour interaction especially in the larger letter rows. It is also useful for validation of visual acuity of malingerers by recording the scores at different distances.[17].

Two versions of the acuity chart designed for use at the reading distance have the same characters as their counterparts in the distance acuity charts. One distinct feature of this set of distance and near word acuity chart is that both charts elicit word acuities. The Snellen distance chart elicits letter acuities whereas the Reduced Snellen chart used at near elicits word acuities. Experienced clinicians have found that there is a significant difference between distance letter acuities and near word acuities when these charts are used. The new Chinese word acuity charts described in this paper should render similar distance and near visual acuity scores since identical characters are used.

Characteristics of the Word Acuity Chart:

A systematic approach to the number of characters in a column, inter-character spacing and intercolumn spacing is incorporated in the design of this chart:

1. Number of characters in a column.

In the conventional charts, there are fewer letters in the larger letter rows. In this new chart, five characters are present in each column for several reasons. First, the probability of guessing one or two characters correctly is very different from that when five or six characters are present. An attempt should be made to have the same probability at different size columns since different individuals may vary in their scores. Second, equal number of characters in each column is necessary for a chart designed to be used at various distances so that there is always the same number in the 'best VA line' at different distances. Third, contour interaction plays an important role in visual acuity measurements. In order to have the same amount of interaction, the number of characters should be consistent in each column.

2. Intercharacter spacing

Maybe investigators have noted that the ability to see isolated symbols is better than grouped symbols.[18 19 20 21 22 23] This has been called the crowding phenomenon or separation difficulty. Flom et al[24] found that in both normal and amblyopic subjects, contours surrounding a test target can adversely affect the detection of its components causing a lower acuity score. As a result, inconsistent interletter spacing in different rows will result in inaccurate recording of visual acuity. It was found that the greatest interaction occurred when the surrounding contour was separated from the test letter by twice the stroke width of the letter, while the greatest separation still affording some interaction is 5.4 times the stroke width (mean of all subjects in the study). Flom [25] suggested that since ordinary scenes contain many near-threshold targets affected by nearby contours, contour interaction should be introduced and controlled in the design of visual acuity test charts. Some recently designed charts have already incorporated this characteristic[6 17]. In this new chart, the separation is equal to the width and height of the characters as recommended by Flom et al.[24]

Davidson[20] proposed a modified method, using contours made up of a solid-bar surrounding the letters. His method is also adopted in this new chart design: characters within a column of neighbouring characters will have sufficiently consistent contour interaction while those at the two ends of the column have solid bars to compensate for the lack of interaction from another character. This design is applied to optimize the consistency of contour interaction.

3. Intercolumn spacing

The separation between columns is equal to the width of the Snellen neighbouring column in order to achieve a consistent amount of contour interaction in both the vertical and horizontal directions.

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