New Visual Acuity Chart : Modification for Clinical Practice and Research

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Abstract

The authors created numeric optotypes by steps following the standard Sloan letters and developed a visual acuity test chart using Logarithm of the Minimal Angle of Resolution (Log MAR) such as the Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Legibility of new numeric optotypes was presented in per cent of correct response at threshold. Only seven numbers (0, 2, 3, 5, 6, 8, 9) were used as optotypes and the average of per cent of correct response at threshold equal to 80.7 which was slightly less than standard Sloan letters (82%). The comparison between results of visual acuity level from the new chart and ETDRS showed that the ETDRS chart was slightly more legible than the new chart. It can be used universally especially with Thai people for clinical practice and research.

Key word : Sloan Letters, Visual Acuity Test Chart, Log MAR Chart, ETDRS Chart

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The visual acuity (VA) test chart most commonly used for literate people in Thailand at present is the "Snellen chart", which has numeric optotype (but characters of number are varied by manufacturing). This chart was not accepted by the universal committee [National Academy of Sciences-National Research Council (NAS-NRC), Consilium Ophthalmologicum Universale (COU), International Organization of Standard (ISO)][1-3].

The disadvantages of this chart are :

1. The optotype varies in legibility per letter and per line.

2. The number of letters per line are not equal in each line.

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3. Progression of letter size is not regular.

4. The spacing and arrangement are not adjusted properly.

5. The testing distance is not accepted as standard.

It is essential to standardize a visual acuity test so that the validity and reliability of the test can be evaluated. Logarithm of The Minimal Angle of Resolution (Log MAR) charts such as Bailey-Lovei chart[4], the Early Treatment Diabetic Retinopathy Study (ETDRS) visual acuity chart[5-8] were accepted as standard charts but their optotypes in English letters are not appropriate for most Thai people. A version with numeric optotypes would be beneficial for both clinical practice and research design. For these reasons, the authors developed a numeric VA chart step by step, similar to the standard Sloan letters (Fig. 1)[9,10]. First, the authors designed characters with a number range from 0 to 9 with a total of 5 x 5 units and a stroke width or gaps equal to 1 unit (Fig. 2). Second, their legibility was tested to see whether they were comparable to the Sloan letters. Third, all data was analyzed and only numbers that had legibility or difficulty approximate to Sloan letters were chosen. Fourth, a numeric visual acuity chart was created using the same method as the Log MAR chart. Finally, the validity of this new chart was checked.

MATERIAL AND METHOD

Subjects

The patient groups were recruited from the outpatient clinic, Department of Ophthalmology,

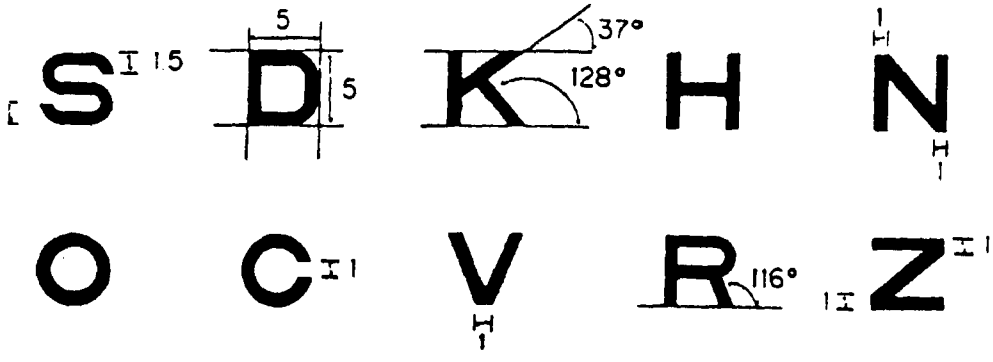

Fig. 1. Specification for the Sloan letters.

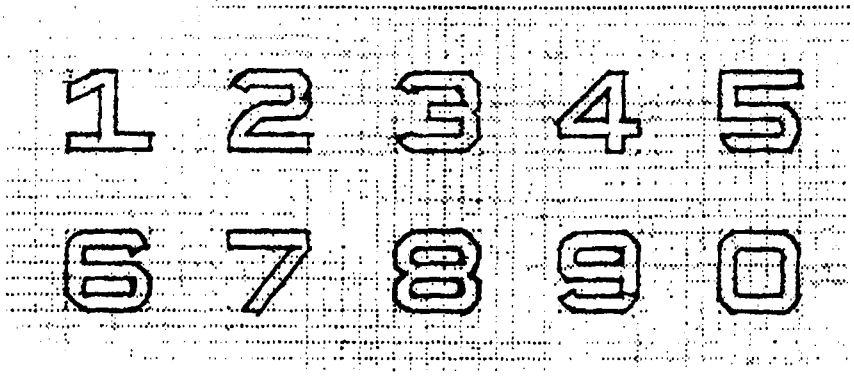

Fig. 2. Specification of the characters of developing numeric optotypes.

Chulalongkorn University. The first group consisted of 314 patients (180 men and 234 women, VA level ranged from 20/15 to 20/200). Data from the first group was used to test for legibility of numeric optotypes. The second patient group consisted of 73 patients, 142 eyes, 238 data (21 men and 52 women, VA level ranged from 20/15 to 20/200) used to test the validity of the newly developed chart by comparing with the ETDRS chart.

Study design

1. The authors used the same method to test legibility of numeric optotypes as previously used to test for Sloan letters by finding out per cent of correct response at threshold (Table 1)[8]. 2. Only numbers that had a legibility comparable to Sloan letters were selected to develop the new visual acuity chart. 3. Arrangement of numbers in lines and line legibility was adjusted by standard means. 4. Finally, the new numeric visual acuity chart was tested for standardization by comparing the number of optotypes read correctly between the ETDRS chart and the new chart.

Statistics

Simple statistical analysis was used to test the legibility of optotypes by calculating the per cent of correct response at threshold. Means and deviations were used in selection of optotypes. For comparison with the standard ETDRS chart, the statistical methods recommened by Brand's in 1986 were used[11].

RESULTS

Legibility of new numeric optotypes was presented in per cent of correct response at threshold (Table 2) and then the legibility of these numeric optotypes were compared with the standard Sloan letters which had an average per cent of correct response at threshold = 82 per cent[7,9,12]. Only numbers that had a deviation equal or less than 10 per cent were selected and ranged between 72-92 per cent, so, numbers 1, 4, 7 were excluded. Only seven numbers (0, 2, 3, 5, 6, 8, 9) were used as optotypes and the average of per cent of correct response at threshold was now equal to 80.7 per cent, which was slightly less than the Sloan letters.

To create testing visual standards as accepted universally, the following items were used as[2,5-7,13].

1. The testing distance was 4 meters.

2. The size was progression by 0.1 log unit (or 1.2589 ratio) The letter sizes ranged from 58.18 to 2.92 mm, providing a visual acuity equivalent of 4/40 to 4/2 (6/60 to 6/3 or 20/200 to 20/10) at a distance of 4 m.

3. The numbers of letters per line ranged from 5 to 10 and equal in each line.

4. There was approximate line difficulty or legibility.

5. There was minimal or no dependency clues of the sequence of letters.

6. The spacing and arrangement were designed as space between letter equal to one letter width and space between line equal to height of letter of the next lower line.

Table 1. Degree of difficulty of Sloan letters.

Sloan letters	% correct at threshold	Deviation
Z	94.0	12.0
N	91.6	9.6
H	89.3	7.3
R	86.3	4.3
V	84.6	2.3
K	82.1	0.1
D	79.5	-0.5
C	71.4	-10.6
O	71.0	-11.0
S	70.6	-11.4
Average	82.0	

Table 2. Numeric optotypes legibility shown as per cent of correct response at threshold and deviations from mean.

Number	%of correct response at threshold	Deviation
0	80.7	+0.1
1	93.3	-
2	83.6	+3.0
3	88.5	+7.9
4	99.4	-
5	82.4	+1.8
6	79.5	-1.1
7	100	-
8	72.4	-8.2
9	74.2	-6.4

Average for 10 numbers = 85.8%, median = 82.5%
for 7 numbers = 80.6%, median = 80.7%

Table 3. Line legibility shown as per cent of correct response at threshold and deviations from mean.

Line content	Line legibility/ difficulty scores	Deviation (%)
2 3 5 6 8	406.4	+5.5
0 3 5 6 8	403.5	+2.6
2 3 5 8 9	401.1	+0.2
0 2 3 8 9	399.4	-1.5
0 2 5 6 8	398.6	-2.3
2 3 6 8 9	398.2	-2.7
0 3 5 8 9	398.2	-2.7
0 2 5 8 9	397.3	-3.6
Average	400.9	

Table 4. Difficulty scores for ETDRS chart.

Line content	Line legibility/difficulty scores
NCKZO	410.0
RHSDK	407.8
DOVHR	410.7
CZRHS	411.6
ONHRC	409.6
DKSNV	408.4
ZSOKN	409.3
CKDNR	410.9
SRZKD	412.5
HZOVC	410.3
NVDOK	408.8
VHCNO	407.9
SVHCZ	409.9
OZDVK	411.2

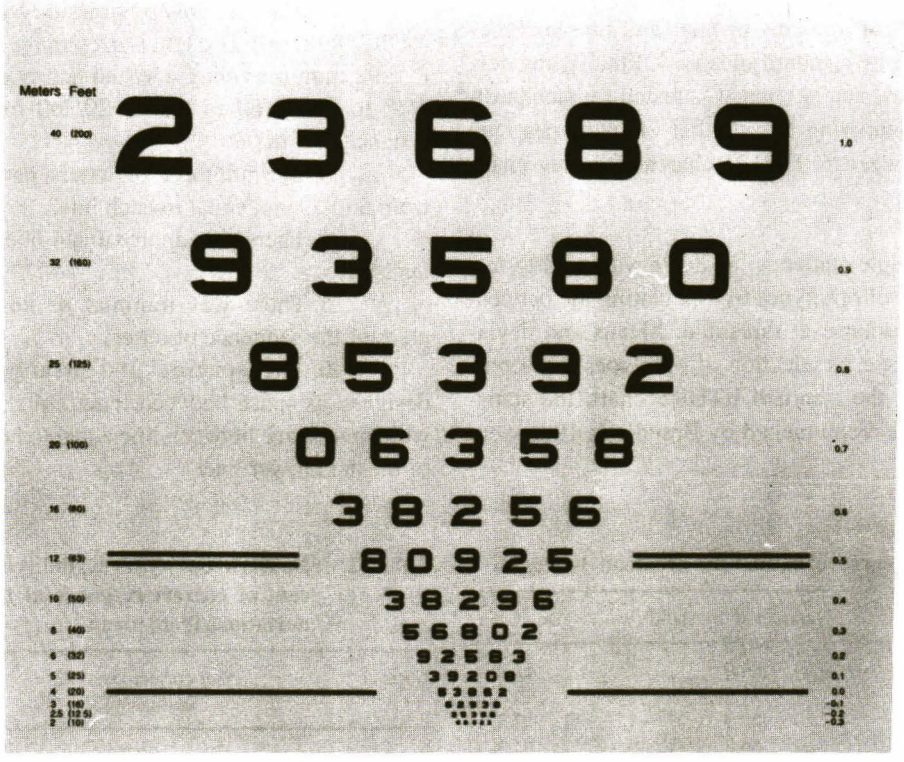

Fig. 3. New numeric visual acuity chart.

7. Standard physical characteristics of the chart - the chart was 63.5 cm wide and 60.3 cm high. A light box accommodated the charts and produced standardized illumination (at least 80cd/m^2)(6).

So, the new chart was developed using these guidelines. Since, each line contained 5 optotypes, 5 from 7, equal to 21 combinations were selected. Line legibility was calculated from summation of each

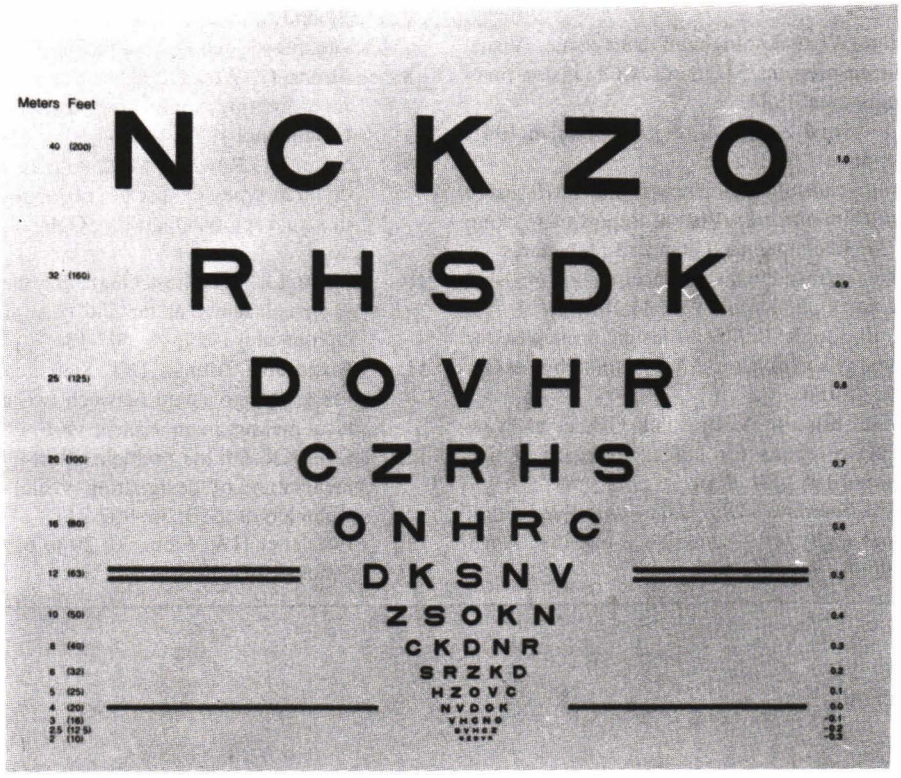

Fig. 4. One of the three ETDRS visual acuity charts.

number legibility in that line. The authors chose lines that had intermediate legibility (Table 3) compared with the ETDRS chart (Table 4), then the numbers were arranged in line with no secondary clues. Eventually, the new numeric visual acuity chart was developed (Fig. 3) compared with the ETDRS chart (Fig. 4) by controlling environment factors such as illumination, contrast and testing distance[6,13].

Between the two methods of visual acuity measurement, i.e. ETDRS and the new VA charts, the mean difference was 1.69 with the standard deviation of the difference of 3.51. The distribution of the difference followed the normal distribution. The authors calculated the 95 per cent confidence interval (95% CI) of the mean difference and both the upper and lower limits of agreement according to Bland's recommendation in 1986. The 95% CI of mean difference was 1.24 to 2.14, the upper limit of agreement was 8.57 (95% CI, 7.80 to 9.34), and the lower limit of agreement was -5.19 (95% CI,-5.96 to-4.42).

DISCUSSION

These new numeric optotypes seemed to be slightly more difficult to recognize when compared to the Sloan letters in the ETDRS chart because the letters are more legible than the numbers. Nevertheless, these new optotypes are more appropriate for Thai people. All data analyzed was specific for these unique characters of numbers. Although there may be some defects in this research, the reliability of the test was not included in the determination, only the validity of the new test chart was interpreted. The reason being that there were limitations in testing each patient several times for reliability of the test chart.

SUMMARY

A new numeric visual acuity chart with optotypes that could generally be accepted as the standard like the ETDRS chart has been developed.

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อุปกรณ์วัดสายตาแบบใหม่ : ประยุกต์เพื่อใช้ในทางคลินิกและการวิจัย

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ผู้วิจัยได้ออกแบบตัวเลขตามมาตรฐานของ Sloan letters ซึ่งเป็นตัวอักษรภาษาอังกฤษสำหรับใช้วัดสายตา โดยได้ตัวเลข 7 ตัว คือ 0, 2, 3, 5, 6, 8, 9 ที่มีค่าของการอ่านง่าย (Legibility) วัดออกมาเป็นเปอร์เซ็นต์ของ correct response at threshold เท่ากับ 80.7 น้อยกว่าค่า 82% ของ Sloan letters เพียงเล็กน้อย และได้สร้างอุปกรณ์หรือแผ่นวัดสายตา โดยใช้ตัวเลขเหล่านี้ตามมาตรฐานของ Logarithm of the Minimal Angle of Resolution (Log MAR) ตามแบบ Early Treatment Diabetic Retinopathy Study (ETDRS) และเมื่อนำมาเปรียบเทียบกับอุปกรณ์หรือแผ่นวัดสายตา ETDRS แล้ว ปรากฏว่าแผ่นวัดสายตาใหม่ที่เป็นตัวเลขนี้อ่านยากกว่าเล็กน้อย

อุปกรณ์หรือแผ่นวัดสายตาแบบใหม่ที่ใช้ตัวเลขนี้ สามารถใช้ได้ทั่วไป โดยเฉพาะในคนไทย สำหรับการตรวจรักษาทางคลินิกและการวิจัย

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