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Snellen-Lit: An Innovative Miniature Snellen Chart For Space Optimization

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Abstract

Space constraint is a major challenge in ophthalmic practice where the standard distance of 6 meters may be unavailable in the triage or consulting room. The objective was to produce a miniature space-saving vision testing chart called Snellen-lit that is not inferior to the standard Snellen's chart in terms of reliability, ergonomics and reproducibility. Literature search was conducted on the subject related to vision testing specifically using "Snellen's acuity chart construction" as key words. Snellen-lit was constructed with CorelDRAW tool with data obtained from Pythagoras theorem and trigonometry calculations of tan theta *(θ)*. Theta being 5 minutes of arc, and it is the visual angle subtended at eye's nodal point. All calculated distances from standard Snellen's chat were halved such that visual angle of 5 minutes of arc was applicable to Snellen-lit.

The result was that Snellen-lit can be used at 3 meters and still maintains the same vision annotation as standard Snellen's chat read at 6 meters without compromising accuracy and reliability.

It is concluded that among the vision testing tools, Snellen's chart remains the commonest in clinic and research settings. Any innovative idea that enhances its applicability without jeopardizing its accuracy, especially innovation that is cost-effective, is a useful addition to vision testing armamentarium. There is a need for real life comparison between standard Snellen's chart read at 6 meters and Snellen-lit read at 3 meters in clinic setting for concordance or discordance.

Keywords: Snellen's chart, Snellen-lit, Nodal point, 5 minutes of arc.

Introduction

Space constraint continues to be a major challenge in ophthalmic practice where a standard distance of 6 meters is required in a consulting room or triage to determine visual acuity. Many consulting rooms are less than 6 meters because the facilities are rented and were not originally designed to be for ophthalmic consultations. Electronic chats that allow vision determination at varying distances, though available, are prohibitively expensive.[1] Dongles that enable a computer or a television set have visual acuity chat capability are also available. However, the extra costs incurred in acquiring the systems pose additional financial burden. An age-long practice is to place a mirror 3 meters away from reversed Snellen's acuity chart, making use of mirror's optical principles to double clinic room space and reverse the reversed Snellen chart. But this does not obviate the need for extra wall space, injury from a breakable mirror and an arguable subtle image imperfection possibly linked with looking at an image rather than directly into the object of concern. Snellen-lit (figure 1), coined by the author to represent "little Snellen" is an innovation aimed at creating an aesthetically appealing space-saving vision chat that is not

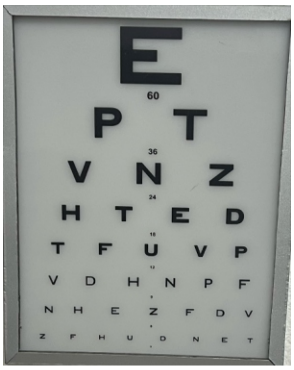

Figure 1: Snellen-lit

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inferior to the standard Snellen's chart in terms or reliability, ergonomics and reproducibility.

Original Snellen's Chart

Snellen chart consists of well-structured alphabetical, numerical or figurative optotypes that are geometrically arranged to enable subjective quantification of vision (visual acuity determination). It was designed by Dr. Herman Snellen in 1862, a Dutch Ophthalmologist.[2-5]

The chart contains rows of diminishing optotypes in black letters against a white background, often with background illumination to yield a high contrast. Each row is assigned a number indicating the distance in meters (feet in American notation) at which a person with normal visual acuity should correctly identify the letters or figures[6-8]. These pre-determined numbers in most charts are 60, 36, 24, 18, 12, 9, 6, 5 and 4.

Principle of Original Snellen Chart Design

Snellen chart is designed to measure visual acuity in angular terms. According to Snellen, interconal distance (distance between two cone photoreceptors) is about 0.004mm or one minute of arc.[8-10] Consequently, for an optotype to be discernable as being separate from the next optotype, there must be a minimum distance of 0.004mm or one minute of arc between them (figure 2).

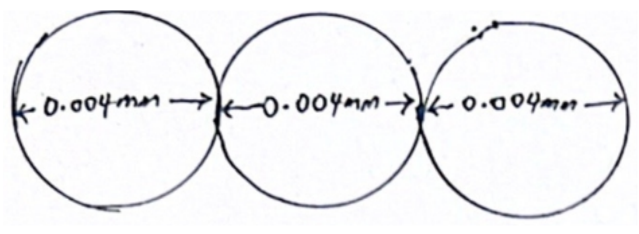

Figure 2: Cone's diameter

Based on this principle, the smallest object which can be resolved or seen by the eye subtends the same visual angle (of 1 minute of arc) at eye's nodal point same as a cone photoreceptor. Each optotype, however, is constructed such that it subtends 5 minutes of arc at eye's nodal point, which is located just behind the posterior capsule of the crystalline lens on the visual axis.[2,8] (figure 3).

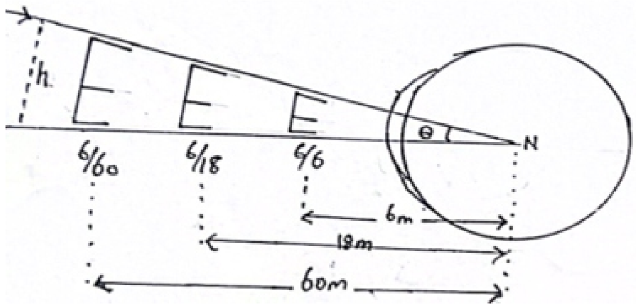

Figure 3: Visual angle

By convention, Snellen's visual acuity is not specified in angular terms but uses a notation in which the denominator is the distance being tested (in feet or meters), and the numerator is 6 meters or 20 feet, a distance universally accepted that all incident rays are parallel (carrying zero vergence power).[8,11-13] Snellen chart provides an awesome possibility where an object that should have been placed 60 meters to be visualized is positioned just at 6 meters in the clinic for patient to visualize. A patient who is able to identify the first optotype of Snellen chart (the 60-line) is said to have a visual acuity of 6/60 or 20/200. Meaning the patient read at 6 meters what a normal eye could read if placed 60 meters away. If same patient reads the third line (the 24-line), it is recorded as 6/24, meaning, the patient read at 6 meters what a normal-sighted person would read at 24 meters. With Snellen-lit, it is now possible to halve testing distance to 3 meters without compromising reporting notation or a need for mirror.

Principle of Snellen-lit design

Using Pythagoras' theorem[8,14,15] which states that tan Theta (**θ**) is opposite over adjacent, it then means that from figure 3 above, theta **θ** or 5 minutes of arc (the visual angle subtended) at eye's nodal point, N, is opposite (height, h, of optotype) over adjacent (in this instance, could be 6, 9, 12, 18, 24, 36 or 60). Meaning if optotype's height is to be calculated at 6 meters, then:

Tan 5' = h/6 ……………………….Equation 1

Calculation of optotype's height

From trigonometry, the equation above can be rewritten as:

h = tan 5' x 6. …………………….. Equation 2

now, 5 minutes of arc can also be translated as 5/60 degree as it takes 60 minutes to make a complete cycle.

Equation 2 could then be re-written as:

h = tan 5/60 x 6 .... Equation 3

tan (5 minutes of arc or 5/60 degrees) approximately equals to 0.001454.

h = 0.001454 x 6 .... Equation 4

h = 0.00872 meters or 8.7 millimeters .... Equation 5

to calculate h when optotypes are 60, 36, 24, 18, 12, 9, 5, 4 meters away and subtending 5 minutes of arc, multiply 0.001454 by 60, 36, 24, 18, 12, 9, 5 and 4 in turn. The results are tabulated in table 1.

Table 1: Heights of optotypes at specified distances from the eye

SN	Tan 5/60	Optotype distance (meters)	Heights in meters	Heights in millimeters
1	0.001454	5	0.00727	7.3
2	0.001454	6	0.00872	8.7
3	0.001454	9	0.01309	13
4	0.001454	12	0.01745	17.5
5	0.001454	18	0.02617	26.2
6	0.001454	24	0.03490	34.9
7	0.001454	36	0.05234	52.3
8	0.001454	60	0.08724	87.2

Each optotype is made up of 25 equal square boxes (figure 4). The entire 25 square boxes subtend 5 minutes of arc at the nodal point of the eye. On the other hand, each row or column of square boxes that sum up to 25 boxes subtends one minute of arc at the nodal point of the eye. Optotypes are constructed by shading the requisite square boxes to form a letter.

In the design of Snellen-lit, 5 minutes of arc (visual angle) is maintained by utilizing 3 meters instead of 6 meters as the standard distance. Similarly, all distances in the standard Snellen chart calculations are halved to maintain same visual angle such that reading the Snellen-lit at 3 meters gives a translation as though it was read at 6 meters. Following calculation, table 2 shows the heights of the optotypes for Snellen-lit which is essentially half of the figures in table 1.

To get the height of each of the 25 boxes that make up an optotypes, divide each height in millimeters by 5 (i.e. find the 1/5 of each height in milliliters).

Table 2: Snellen-lit's optotype height calculations

SN	Tan 5/60	Standard Optotype's distance (meters)	Snellen-lit optotype's distance (meters)	Snellen-lit optotype's heights (meters)	Snellen-lit optotype's heights (millimeters)
1	0.001454	5	2.5	0.00364	3.7
2	0.001454	6	3	0.00436	4.4
3	0.001454	9	4.5	0.00654	6.6
4	0.001454	12	6	0.00872	8.7
5	0.001454	18	9	0.01309	13
6	0.001454	24	12	0.01745	17.5
7	0.001454	36	18	0.02617	26.2
8	0.001454	60	30	0.04362	43.6

Table 3 juxtaposes the heights in standard Snellen chart and Snellen-lit.

Table 3: Sizes of each of the 25 square boxes in standard Snellen's chart and Snellen-lit

SN	Standard Snellen optotypes' heights (millimeters)	Height of each square box of Standard Optotypes (millimeters)	Snellen-lit optotypes' heights (millimeters)	Height of each square box of optotypes in Snellen-lit (millimeters)
1	7.3	1.5	3.7	0.7
2	8.7	1.7	4.4	0.9
3	13	2.6	6.6	1.3
4	17.5	3.5	8.7	1.7
5	26.2	5.2	13	2.6
6	34.9	7.0	17.5	3.5
7	52.3	10.5	26.2	5.2
8	87.2	17.4	43.6	8.7

CorelDRAW optotype construction

CorelDRAW is one of the tools that could be used for optotype construction. From table 3 above, using a CorelDRAW, optotypes are constructed as depicted in figure 4. In figure 4, letter E is constructed for both standard Snellen chart and Snellen-lit. Each row of optotypes should have equal separation. Twenty millimeters is adequate and would prevent undue over-crowding. Optotypes on the same horizontal line should be well-centered using the first uppermost optotype E as a guide for

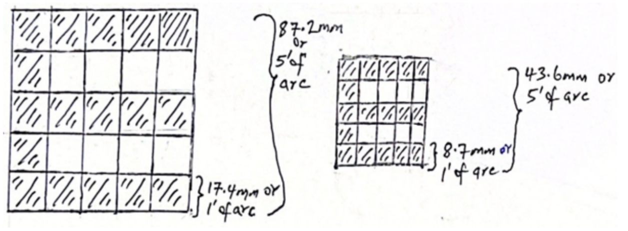

Figure 4: Optotype E in the standard Snellen Chart (left) scaled down to optotype E in Snellen-lit (right)

centration. Then the space separating each optotype horizontally should be equal as depicted in the final Snellen-lit chart in figure 1.

Final Snellen-Lit Design (Figure 1)

Figure 1 is the board-borne illuminated Snellen-lit. The chart constructed with CorelDRAW is taken to an artist for printing on a plastic plate. Akin to how an illuminated signpost is made, the chart is placed in front of a rectangular brightly illuminated opaque casing to produce a board-borne illuminated Snellen-lit. The illumination should be diffuse and be devoid of shadows of wire contained in the casing. The wiring could be done to allow for remote switch control or use of remote-control wall adapter.

Use of Snellen-lit

It is read at 3 meters unlike the standard Snellen chart that is read at 6 meters. All other protocols regarding illumination, testing each eye one after the other, pin-hole testing and final recording are the same. For instance, if a patient reads the first optotype designated 60, the recording is 6/60, same as the standard Snellen chart. The same goes for other optotypes.

Conclusion

Snellen chart is still the commonest vision testing tool despite the availability of other reliable charts. Although with short-comings of being easily memorized (alternating different optotype designs ameliorate this demerit), over-crowding effect and variable optotype legibility, it remains the most popular in clinic and research settings. Any innovative idea that enhances its applicability without jeopardizing its accuracy, especially innovation that is cost-effective, is a useful addition to vision testing armamentarium. There is a need for real life comparison between standard Snellen chart read at 6 meters and Snellen-lit read at 3 meters in clinic setting for concordance or discordance.

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