# *Lab 4 – Visual Acuity*

Optometrists frequently test vision using the Snellen visual acuity (VA) test.
Q. Why are we interested in testing visual acuity?
A. There are at least three reasons:

- Guide us in refractions.
- Helps diagnose diseases that affect vision
- Physical examination – documenting visual performance.

Q. Why is it important to have accurate and repeatable visual acuity measurements?
A. To know whether or not changes in VA are significant, or not.

## STANDARD SNELLEN VISUAL ACUITY CHART

Consider some of the features of a standard Snellen VA chart.
Q. What is the progression of letter sizes?
A. List the Snellen denominator (20/x) of the sizes used. x= 400, 200, 100, 80, 70, 60, 50, 40, 30, 25, 20, 15, 10

Q. Do all the lines (rows) have a uniform size progression in terms of difficulty of reading?
A. No. The visual difficulty increments are smaller at the bottom of the chart.

Q. Not all letters of the alphabet are used in a Snellen chart. Why are some used and some are not?
A. Some letters are too easy to miss and some others are too hard to miss.

Q. How do you record the VA if a person reads only part of a line?
A. We give credit for the entire line if a person reads half of the line, and then append the line score with ± letters.

Q. How might this introduce error into VA measurements?
A. Vague imprecise data makes it harder to make clinical decisions that depend on VA data.

## LOGMAR VISUAL ACUITY CHARTS

Most optometrists and ophthalmologists test visual quailty using the Snellen Visual acuity tests, which was developed in 1862. The commonly used clinical VA tests were not precise enough for the National Eye Institute when they began the Early Treatment of Diabetic Retinopathy Study (ETDRS) in 1979, so they established a better system for testing VA, now known as the ETDRS chart. It is now the preferred VA system for scientists studying everything from ocular disease to refractive surgery. When you read eye research articles, you will frequently encounter references to the ETDRS chart or logMAR visual acuity. The purpose of this lab is to familiarize you with this system.

### Size progression

One of the important features of the ETDRS chart is the progression of letter sizes. It is a **logMAR chart**, which means that the letters change in size from line to line in equal steps of the log of the minimum angle of resolution (MAR).

Q. What is meant by the minimum angle of resolution in a VA test? Refer to Schwartz Fig. 7-19 and Figure 1 below.
A. One stroke or major feature of a Snellen letter.

Figure 1. The MAR is the angular width of one bar.

Q. What is the MAR for a 20/20 Snellen letter (in arc minutes)?
A. 1.0 arc minutes

Scientists have discovered that sensory increments generally follow a logarithmic rather than linear scale. If you want to create a VA chart that has a uniform change in difficulty from line to line, it is better to change letter size in logMAR steps, rather than the steps used in the standard Snellen test.

Complete the table below, computing the MAR for the Snellen letter sizes (Snellen denominators listed). Then enter the log of each MAR in the bottom row.

**Snellen denominator equivalents of logMAR**

| **20/x** | 10 | 12.5 | 16 | 20 | 25 | 32 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MAR** | 0.5 | 0.625 | 0.8 | 1 | 1.25 | 1.6 | 2 | 2.5 | 3.15 | 4 | 5 | 6.25 | 8 | 10 |
| **logMAR** | -0.3 | -0.2 | -0.1 | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |

Q. What is the interval between lines on a logMAR scale?
A. 0.1 logMAR steps.

**Choice of letters**
Q. Which letters are used in the ETDRS chart?
A. C, D, H, K, N, O, R, S, V, Z

This is the **Sloan letter set** and these letters in this font are supposed to be equally difficult to read.

**Scoring the results**
Q. What other differences do you notice between the ETDRS chart and the standard Snellen chart?
A. Five letters in each line, same proportional spacing, so it forms a pyramid pattern.

On the ETDRS chart, since every line has 5 letters and each letter is equally difficult to read, each letter is scored as 1/5 of a line. Since each line progresses 0.1 logMAR units, each letter is credited as 0.02 of a logMAR unit. To get full credit for one line, you must read all five letters. However, you receive partial credit if you miss some letters on a line. For example, if a person sees all of the logMAR 0.3 line (20/40) and two letters from the next line ($20/40^{+2}$), it is scored as 0.3 *minus 0.02 for each additional letter read from the next line*. That is, 0.3 - (0.04) = 0.26. If the person could read all of the next line, his logMAR acuity would have been 0.2. Similarly, if a person reads logMAR line 0.2 (20/32), but misses two letters, you would *add 0.02 for each letter missed*. In example, the equivalent of $20/32^{-2}$ is a logMAR score of 0.2+0.04 = 0.24.

Note the following features of the ETDRS chart:

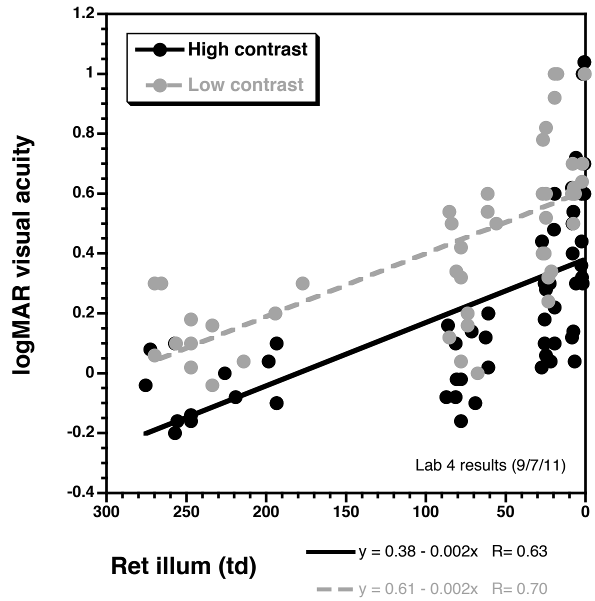
- The 20/20 letter has a logMAR value of 0.
- Letters smaller than 20/20 have negative logMAR values.
- A smaller (more negative) logMAR score indicates better acuity (as with the Snellen denominator).
- A larger positive logMAR value indicates worse visual acuity.

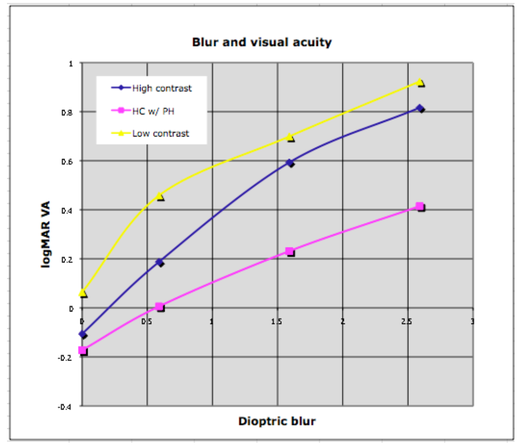
**Experiment.**
Working in pairs, select an eye with good vision and measure how high and low contrast logMAR VA change as a function of retinal illumination. Use ND filters to reduce luminance of the VA charts. Keep pupil size constant (4 mm etc).

| | **HCVA** | | **LCVA** | | | |
|---|---|---|---|---|---|---|
| **ND** | 20/x ± letters | calc LogMAR | 20/x ± letters | calc LogMAR | Pupil diam (mm) | Retinal illum |
| 0.0 | | | | | | |
| 0.3 | | | | | | |
| 0.5 | | | | | | |
| 0.7 | | | | | | |
| 1.0 | | | | | | |
| 1.5 | | | | | | |
| 2.0 | | | | | | |

HC chart background luminance ____________ LC chart background luminance _______________

**Homework assignment**. Enter your results on the lab computer and plot logMAR VA as a function of retinal illumination for high and low contrast. Describe how retinal illumination affects high and low contrast VA.




**Results from Lab 4.**
High and low contrast VA as a function of retinal illuminance (left chart) and as a function of dioptric blur (right chart).

*Retinal illumination and VA*
The left chart shows that visual acuity decreases as retinal illumination decreases, and the relationship can be described fairly well by a straight line. The correlation coefficient for high and low contrast, respectively are r=0.63 and r=0.70, which indicate fairly good correlations. Note however that there is much more scatter of data points for very low retinal illumination. The two lines are parallel, so the rate of change in visual acuity is the same for both high and low contrast. The low-contrast line is higher, indicating that over the same range of retinal illumination values low contrast acuity is worse. Data points are missing in the range of 170 to 110 trolands. Perhaps a future experiment should include measurements in that range. A practical implication of this relationship is that, vision is worse when retinal illumination is low. Therefore, if a person cannot see an objects well, such as a near visual acuity chart, you can improve vision by increasing luminance of the chart. It also shows that your results in a near visual acuity test can depend on luminance of the chart, so you should use a standard light level when measuring near VA.

*Dioptric blur and VA*
The right graph shows results from a previous year, where logMAR VA is plotted as a function of optical blur caused by putting plus lenses in front of the subjects' eyes. The correlation (r=0.99) between optical blur and VA was much higher, showing that blur can be a significant factor in the VA measurement. The slopes of the lines for low contrast (yellow) and high contrast (dark blue line) are roughly parallel, so neither one is significantly more sensitive to changes in blur. Therefore, there is no significant advantage to using a low contrast chart over a high contrast chart to measure optical blur. The yellow curve is higher, indicating that visual acuity is worse for low contrast than high contrast.