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LogMAR IS NOT A PROPER MEASURE FOR VISUAL ACUITY ASSESSMENT

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Subject under consideration

The basic term **"MAR"** is an acronym for **Minimum Angle of Resolution.** MAR means the minimum angular distance between two small test objects (a pair of points, two parallel lines, two periods of a grating, etc.) at which these objects can be just perceived as separate. MAR is also named ***resolution threshold***. The reciprocal value, 1/MAR, corresponds to the term ***resolving power*** widely used in optics to characterize quality of optical devices.

The term **"LogMAR"** was embedded in the ophthalmic literature in 1980s by R.Ferris and his colleagues from the National Eye Institute (USA) who tried to elaborate a convenient and standardized method of visual acuity (VA) measurement for the Early Treatment of Diabetic Retonopathy Study (ETDRS). They had chosen Sloan letters as the test stimuli and used the so-called "LogMAR design" for the VA chart layout. In such VA charts, the conventional normal level (MAR=1′) corresponded to zero value (since log1=0), and the changes of the letter sizes from line to line and their spacing corresponded to geometric progression with the multiplayer 1.26 (Ferris et al., 1982).

The only reason to choose this multiplayer was the fact that log1.26=0.1 providing a possibility to denote the lines corresponding to different levels of VA by the subscripts that were multiples of 0.1: 0; ±0.1; ±0.2; ±0.3; etc.

It was natural that employment of such charts provoked expressing the results of VA assessment in the values of logMAR shown near the lines.

In its turn, this practice brought to ***a delusion that VA could be measured in logMAR units.***

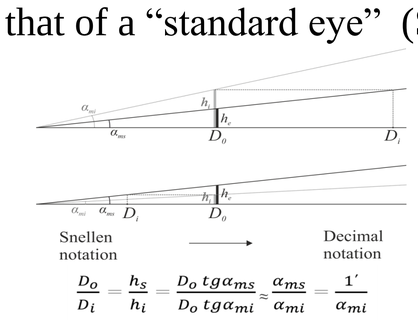
However, it is easy to demonstrate that ***logMAR notation is incompatible with metrological definition "unit of measurement"*** and has other disadvantages in comparison with decimal and Snellen notations of VA.

Analysis

In the *International Vocabulary of Metrology* (2008. *Basic and General Concepts and Associated terms, p. 6.*) one could find the following notion:

"Unit of measurement – real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number."

It's easy to see that such widely used notations of VA as decimal notation and Snellen notation are in agreement with the requirements of metrology. In these VA notations, the value of VA of a subject shows how many times it is better than that of a "standard eye" (StE) with MAR=1′.



$$\frac{D_o}{D_i} = \frac{h_s}{h_i} = \frac{D_o\, tg\alpha_{ms}}{D_o\, tg\alpha_{mi}} \simeq \frac{\alpha_{ms}}{\alpha_{mi}} = \frac{1'}{\alpha_{mi}}$$

D_o –observation distance
h_s –threshold size for StE
h_i – threshold size for a subject
D_i – distance at which the angular size of h_i is equal to 1′.

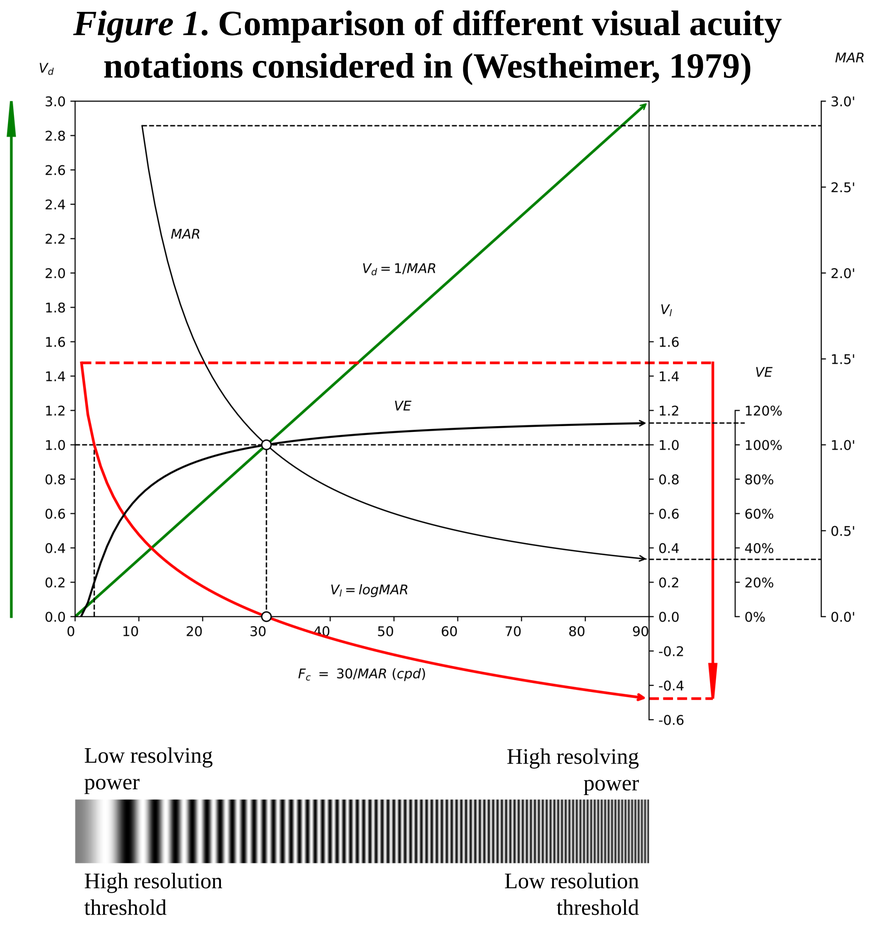
VA can be considered as the resolving power expressed in relation to the resolving power of the standard eye equal to 1/1′.

The situation with logMAR notation is quite different. We couldn't take VA of a standard eye as a measuring unit since log1=0 but division by 0 is impossible. We couldn't also take any other value from the logMAR scale as a unit because it would be problematic to interpret negative values of some ratios.

In fact, logMAR is not appropriate measure of VA as a quality of vision since the scores of quality should rise with improvement of vision while logMAR function behave quite opposite.

To illustrate principal differences between different VA notations, we have plotted corresponding functions on a graph (*Figure1*) where the argument (*x*-axis) is critical spatial frequency, F_c, since F_c gives a vivid idea of low and high VA in agreement with our intuition.

***Figure 1*. Comparison of different visual acuity notations considered in (Westheimer, 1979)**



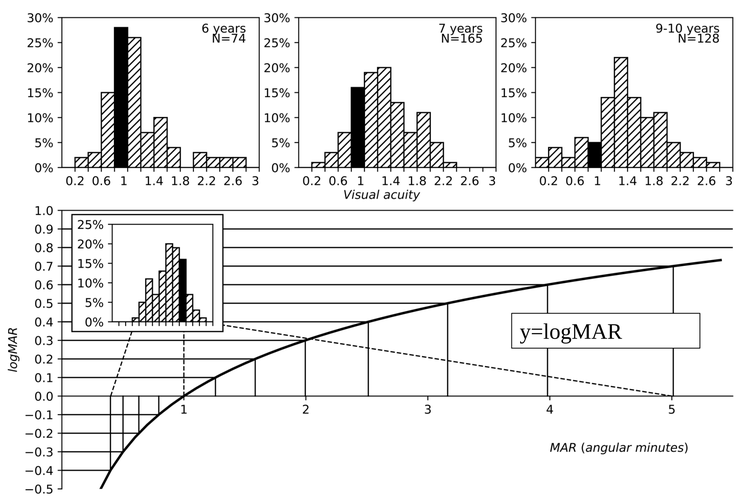
It is clearly seen that two of the VA notations presented – decimal notation (1/MAR) and visual efficiency notation (VE) – give increasing values with increasing F_c (and, therefore, VA), while logMAR notation shows quite opposite behavior, similar to that of MAR. This means that logMAR could be considered as an adequate scaling of MAR (resolution threshold) but not of VA (resolving power).

In *Figure 2*, the logMAR function is plotted on the graph with MAR as the argument (x-axis) to illustrate some other inconveniencies of this VA notation (Rozhkova, 2017). The upper row of the figure presents 3 typical histograms of VA values (in decimal units) obtained in children (Rozhkova & Matveev, 2007). Lower, one of these histograms (for 7-year age) is inverted in left-right direction and placed in such a way that the black column corresponding to VA=1 appeared just above logMAR=0.

It is clearly seen that, in logMAR notation, most 7-year aged children have negative values of VA, and, comparing all 3 histograms, it's easy to conclude that proportion of children with negative logMAR values increases with age. The transition from positive to negative values is not justified physiologically, and there are no evident reasons to introduce negative values of VA in usual clinical practice.

At the same time, in research work, one may choose any notation if it helps to elucidate the essence of a problem or to achieve success.

***Figure 2*. Histograms of binocular visual acuity values (dec. units) in children and logMAR notation**



Conclusions

LogMAR notation of visual acuity doesn't fit the requirements of metrology.
LogMAR with its negative values for excellent vision is not appropriate measure of visual acuity as a quality.
It seems reasonable to recommend employment of traditional decimal and Snellen notations in clinics.

Acknowledgments

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