Electronic Letters to:

Visual Psychophysics and Physiological Optics:
Kilian Schulze-Bonsel, Nicolas Feltgen, Hermann Burau, Lutz Hansen, and Michael Bach
Visual Acuities "Hand Motion" and "Counting Fingers" Can Be Quantified with the Freiburg Visual Acuity Test
Invest. Ophthalmol. Vis. Sci. 2006; 47: 1236-1240 [Abstract] [Full text] [PDF]

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Numerical Imputation for Low Vision States
George F. Reed (26 July 2007)

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Michael Bach (26 July 2007)

Numerical Imputation for Low Vision States

26 July 2007

George F. Reed

Send letter to journal: Re: Numerical Imputation for Low Vision States

Email George F. Reed

Schulze-Bonsel et al.[1] reported a breakthrough in the quantification of low vision designations [i.e., count fingers (CF) and hand motions (HM)] through use of the Freiberg Visual Acuity Test (FrACT). From their analysis we can infer an equivalence between FrACT and the ETDRS procedure within the ETDRS range. We also see that FrACT linearly extends measurements into the low vision range. Given the easy availability of the FrACT system, it is hoped that there will be subsequent confirmatory replications of this study employing larger samples that will better characterize the distribution of numerical measurements in the low vision range.

For investigators who will not apply the FrACT technology, the article offers a small amount of data for arriving at imputation values for CF and HM from direct measurements, as opposed to existing approximate imputations.[2,3,4] Specifically, one may assign to CF the mean logMAR value of the four CF eyes in the dataset and to HM the mean logMAR of the five HM eyes (i.e., set CF to 1.86 and set HM to 2.30).

There remains the issue of incorporating light perception (LP) and no light perception (NLP) in the numerical data. Most investigators, including Schulze-Bonsel et al., make no attempt to do so, reasoning that these are not actual acuity measurements. A more comprehensive perspective recognizes that LP/NLP eyes resolve with decimal acuity zero, and that an eye that progresses from measurable acuity to LP/NLP has experienced the ultimate loss in acuity. If LP/NLP are omitted from the data, such losses are never reflected in the summary statistics of visual acuity.

It is surely defensible to assign decimal acuity zero to LP/NLP, but there is no logMAR equivalent. I suggest that, instead of zero, LP/NLP be assigned the decimal acuity that is halfway between zero and a probable lower bound among HM eyes. This is a notion inspired by the imputation of values below the detection limits of chemical assays.[5] A probable lower bound could be a very low percentile of a reference set of data or merely its minimum, and the midpoint between zero and the lower bound would be an estimate of the point below which no acuity can be measured. For example, with the Schulze-Bonsel et al. data as reference, the minimum decimal acuity is 0.0033, so that the midpoint is 0.00165, and LP/NLP is assigned the logMAR equivalent 2.78. This imputation as well as those above for CF and HM should improve as FrACT measurements of larger samples of low vision eyes reach publication.

George F. Reed
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5. Hornung RW, Reed LD. Estimation of average concentration in the presence of nondetectable values. *Appl Occup Environ Hyg*. 1990;5:46-51.

Author Response: Numerical Imputation for Low Vision States

26 July 2007

Michael Bach

Send letter to journal: Re: Author Response: Numerical Imputation for Low Vision States

Email Michael Bach

We thank Dr. Reed for his thoughtful comments on our paper 'Visual acuities "hand motion" and "counting fingers" can be quantified with the Freiburg Visual Acuity Test'[1] and are glad for the opportunity to reply. We agree with Dr. Reed in most respects and come to a similar conclusion: assign logMAR = 2.7 to LP, but 3.0 to NLP.

Specifically, Dr. Reed argues, "There remains the issue of incorporating light perception (LP) and no light perception (NLP) in the numerical data. Most investigators, including Schulze-Bonsel et al., make no

Email Michael Bach

attempt to do so, reasoning that these are not actual acuity measurements." Here we beg to differ: we did make an attempt to assess LP and NLP, but had to report, "No successful measurement could be performed with the FrACT for LP (n = 2)." We have since tackled this problem again with a larger number of patients, and are currently analyzing the results. So far the values of our 2006 study are closely reproduced both for CF and HM, and in patients with LP still no reliable number can be assigned with FrACT - FrACT just progresses to the largest optotype possible, given distance and screen size.

We agree with Dr. Reed and the general ophthalmic and vision community that acuity should be assessed on a logarithmic scale, hence the use of logMAR or logVA. A decimal value of 0.0 for VA has no logarithmic equivalent, and we would not suggest equating NLP (or, for that matter, LP) with a value of zero decimal acuity. In his letter, Dr. Reed suggests that "LP/NLP be assigned the decimal acuity that is halfway between zero and a probable lower bound among HM eyes." However, this implies a linear scale that we want to avoid when it comes to acuity. We suggest the following line of reasoning:

1. We recognize a need for a compromise: on one hand the concept of visual angle loses meaning at such low acuities; on the other hand it is desirable to assign numbers for quantitative assessment.
2. In the absence of a formal quantitative procedure to assign numbers to LP and NLP, we suggest combining clinical wisdom and smooth progression on the number ray representing acuity. Table 1 lists acuity values from decimal 0.001 to 2.0 in logarithmically equidistant steps by a factor of 0.126 ~ 10^{th} root of ten. Going up and down a line in this table corresponds to equal perceptual distance, regardless of where one starts. FrACT reports results in whatever notation is desired. In the table we distributed FrACT results for CF and HM over three lines each to approximate the actual distribution found.
3. LP and NLP differ significantly and should be represented in this table at places that correspond to their perceptual impact.
4. It is a useful rule of thumb that three lines is significant (three lines correspond to a factor of two in VA, or a difference of 0.3 in logMAR/logVA).
5. We note that the difference between the median FrACT values for CF and HM is four lines.

Combining these thoughts, we suggest placing the value of LP four lines below that for HM (as determined by FrACT), thus at decimal acuity = 0.002 or logMAR = 2.7. This is indicated in Table 1 as "(LP)." By this reasoning NLP should move another four lines down. However, given that this number cannot be obtained quantitatively in any case, and having a preference for round numbers, we suggest moving only three more lines down and assigning 0.001 (decimal acuity, corresponding to logMAR = 3.0) for the category NLP.

We thus arrive at a similar value as Dr. Reed (his 2.78, our 2.7 logMAR) for LP, but propose to assign a logMAR value of 3.0 to NLP.

Decimal Acuity (VA)	logVA	logMAR	Snellen (Imperial)	FrACT
2.00	0.30	-0.30	20/10	
1.58	0.20	-0.20	20/12.5	
1.26	0.10	-0.10	20/16	
1.00	0.00	0.00	20/20	
0.79	-0.10	0.10	20/25	
0.63	-0.20	0.20	20/30	
0.50	-0.30	0.30	20/40	
0.40	-0.40	0.40	20/50	
0.32	-0.50	0.50	20/60	
0.25	-0.60	0.60	20/80	
0.20	-0.70	0.70	20/100	
0.16	-0.80	0.80	20/125	
0.13	-0.90	0.90	20/160	
0.10	-1.00	1.00	20/200	
0.079	-1.10	1.10	20/250	
0.063	-1.20	1.20	20/300	
0.050	-1.30	1.30	20/400	
0.040	-1.40	1.40	20/500	
0.032	-1.50	1.50	20/600	
0.025	-1.60	1.60	20/800	
0.020	-1.70	1.70	20/1000	
0.016	-1.80	1.80		**CF**
0.013	-1.90	1.90		**CF**
0.010	-2.00	2.00		**CF**
0.0079	-2.10	2.10		
0.0063	-2.20	2.20		**HM**
0.0050	-2.30	2.30		**HM**

0.0040	-2.40	2.40		**HM**
0.0032	-2.50	2.50		
0.0025	-2.60	2.60		
0.0020	-2.70	2.70		**(LP)**
0.0016	-2.80	2.80		
0.0013	-2.90	2.90		
0.0010	-3.00	3.00		**(NLP)**

Table 1. Acuity in various formats, progressing in equal perceptual steps from line to line. The values obtained with FrACT for CF and HM are spread out over 3 lines to approximate the distribution found. The proposed values to represent LP and NLP (in parentheses) place these categories in roughly equidistant steps going from CF over HM downwards.

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References

1. Schulze-Bonsel K, Feltgen N, Burau H, Hansen L, Bach M. Visual acuities "hand motion" and "counting fingers" can be quantified with the Freiburg Visual Acuity Test. *Invest Ophthalmol Vis Sci*. 2006;47:1236-1240.