Computer-based assessment of visual acuity: comparison of different psychometric procedures

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Background

A quick and examiner-independent visual acuity (VA) assessment test would be desirable for clinical studies. Vision Chart™ (CSO, Florence, Italy) is a computerised device for VA measurements that allows different methods of presentation of optotypes: EDTRS-chart-like presentation, single-row and single-letter presentation. Letters change randomly, they can be presented manually or by an automated procedure based on QUEST method. QUEST is an adaptive psychometric procedure in which letter sizes are selected to be as close to the current estimate of threshold size as possible (Watson & Pelli, 1983). The measurement procedure begins with a large letter, which is easy to detect. The size is then reduced until the observer makes a mistake, at which point the size is increased until the observer responds correctly, triggering another reversal. After each response, the step-size is reduced and the likelihood is calculated of where the threshold lies.

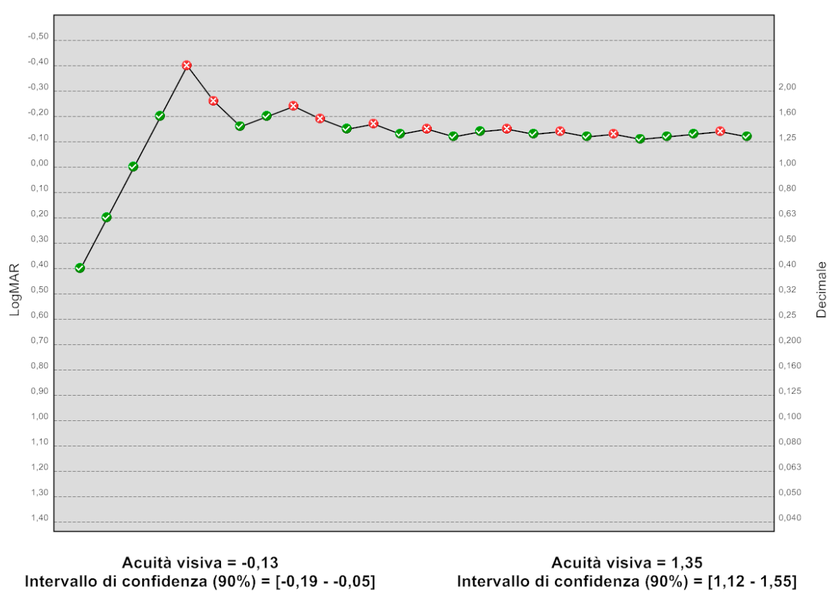


Figure 1: The software generates a graph with all the observer's responses, the VA threshold and the relative confidence interval. Correct answers are shown in green, mistakes in red (Calossi & Boccardo, 2010).

Purpose

Purpose of our study was to validate the QUEST procedure in Vision Chart™, comparing with standard manual procedures of presentation of optotypes (ETDRS-chart-like and single-letter).

Methods

Fifty eyes from 50 subjects (mean age 22, range 18-33) were tested, with a refractive error between 1.125 D and -8.125 D (median 0.00 D). Exclusion criteria were the presence of ocular pathology, amblyopia, and toric contact lens wear. VA was assessed by Vision Chart™, using three methods of presentation in a random sequence: manual chart (subjects must read the central row of a table of 5 rows made of 5 letters each) (MC), manual single letter (5 presentations for each dimension) (MSL), and QUEST single letter (QSL).

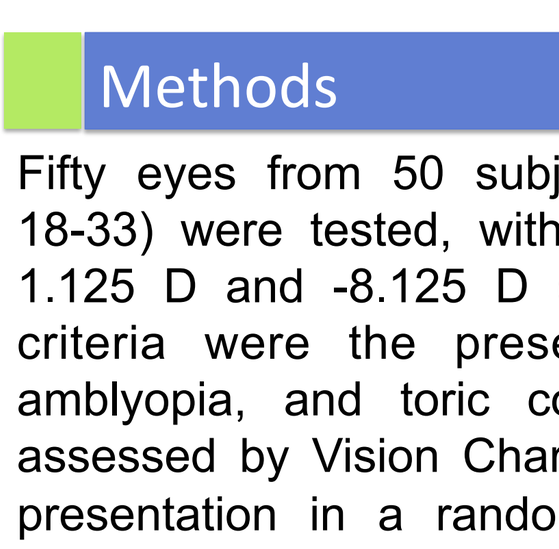


Figure 2: Vision Chart™ ETDRS-chart-like presentation.

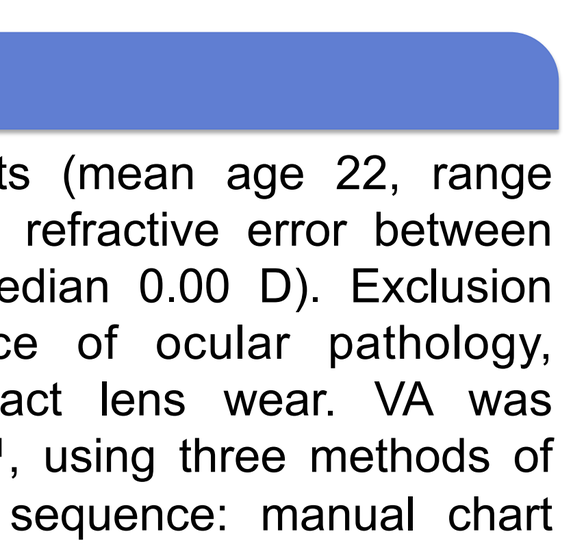
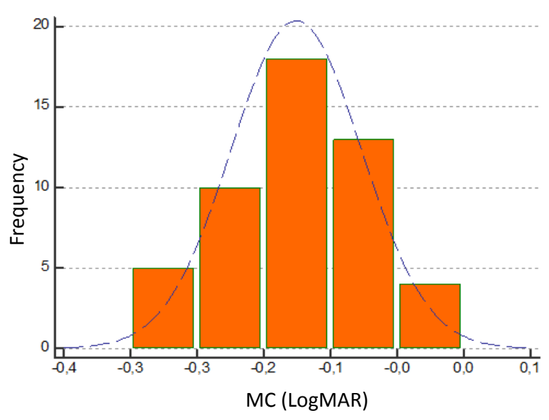


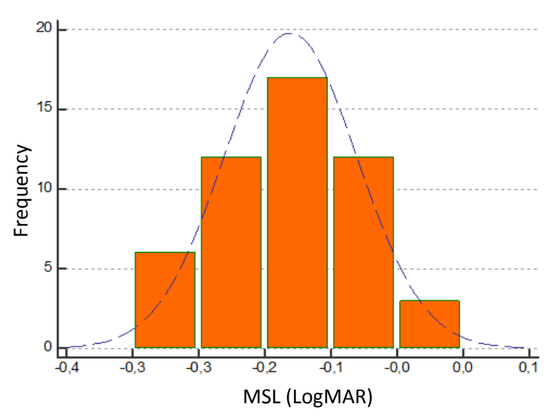
Figure 3: Vision Chart™ single-letter presentation.

Results

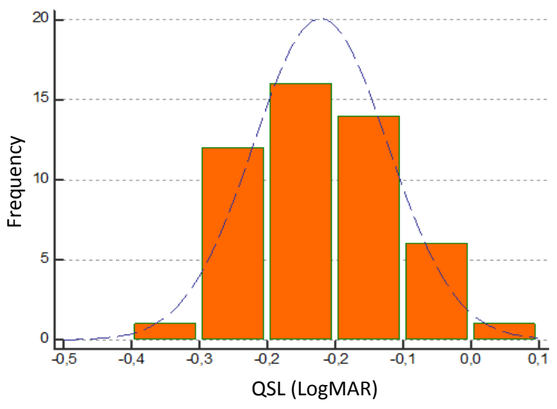
Mean VA was -0.15 ± 0.1 LogMAR for MC, -0.16 ± 0.1 LogMAR for MSL, and -0.18 ± 0.1 LogMAR for QSL. Mean differences were analysed by using the t-test with Bonferroni correction for multiple comparisons, and they resulted statistically significant ($p<0.05$), but clinically irrelevant. Bland-Altman plots show a bias equal to -0.007 ± 0.04 LogMAR between MC and MSL; -0.017 ± 0.08 LogMAR between MSL and QSL; and -0.025 ± 0.09 LogMAR between MC and QSL.



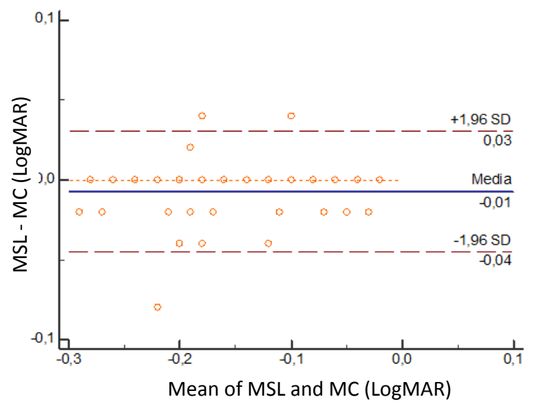
Graph 1: frequency distribution histogram of VA, measured by manual-chart-presentation.



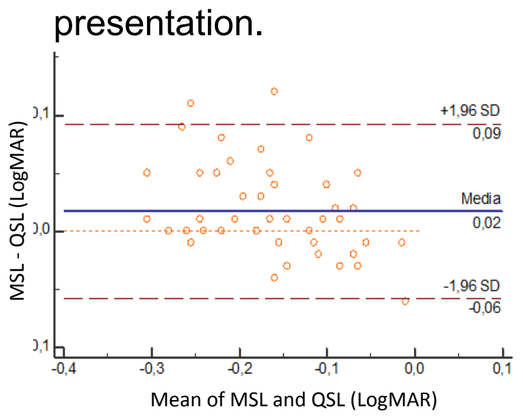
Graph 2: frequency distribution histogram of VA, measured by manual-single-letter presentation.



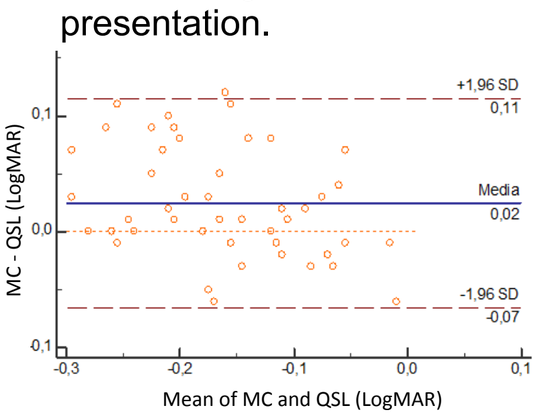
Graph 3: Frequency distribution histogram of VA, measured by QUEST-single-letter presentation.



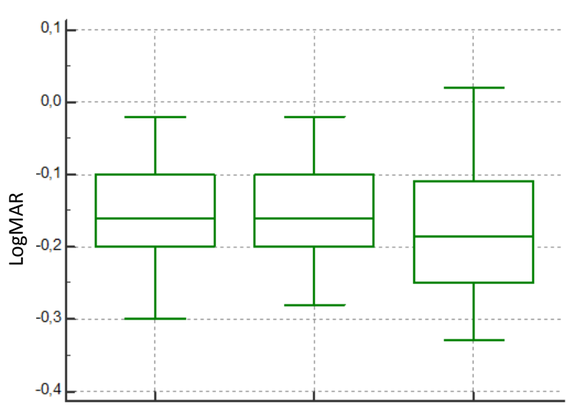
Graph 4: Bland-Altman plot comparing manual-chart and manual-single-letter presentation.



Graph 5: Bland-Altman plot comparing manual-single-letter and QUEST-single-letter presentation.



Graph 6: Bland-Altman plot comparing manual-chart and QUEST-single-letter presentation.



Graph 7: Box-and-whisker plot for manual-single-letter, manual-chart, and QUEST-single-letter presentations. The ends of the box are the first and third quartiles. The horizontal line inside the box is the median. The whiskers extend to the highest and lowest observations.

Conclusions

Differences between the three methods are very small, not greater than one or two letters, and less than the repeatability of the measure of VA (Siderov e Tiu, 1999; Ravikumar, Benoit, Morrison et al, 2018). QUEST, carried out with the Vision Chart™, proved to be effective in reproducing the same results as the ones obtained by an operator performing standard manual procedures for VA assessment. This could be useful to compare measures taken in different settings and to eliminate the variability given by different operators. Further studies are needed in order to evaluate if these results can also be applied to pathological or amblyopic eyes.

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