Comparison of the Measurement of Contrast Sensitivity Threshold using Sine Wave Gratings and Sloan Letters on a LCD-based Testing Screen

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INTRODUCTION

Contrast sensitivity (CS) is an important aspect of visual function. Its measure can provide insight necessary for the diagnosis and treatment of several visual disorders.[1] Historically, printed charts and cards such as the Bailey-Lovie, Pelli-Robson, and Vistech tests have been used to measure CS. These charts utilize different methodologies to determine CS threshold, but generally they use either a Sloan optotype or a sine wave grating (SWG) as the target.

However, many clinicians are moving away from printed charts or projector systems and are now relying upon electronic monitors to provide all the targets for the myriad tests performed during a comprehensive eye exam. To provide clinicians with reliable and updated technology, research is ongoing to develop and test alternative methods of measuring CS using electronically based systems.

The Harris Contrast test (M&S Smart System®) was developed to test CS threshold using two target options displayed on an LCD monitor: a Sloan optotype of various sizes and a SWG of various cycles per degree (CPD). Our preliminary study has demonstrated that CS thresholds as found with the Sloan letters on the Harris test were not significantly different from those found with the paper version of the Bailey-Lovie chart when using a similar methodology.[2]

Until this study, there had been no comparison made of the CS threshold measured using the different targets of Sloan letters and SWG as presented in the Harris Contrast test.

PURPOSE

To compare and contrast two types of contrast target, SWG and Sloan letters, using the Harris Contrast test (M&S Smart System), a computer-based test displayed on an LCD monitor.

METHOD

Data from 109 healthy adults (mean age of 24.5 +/- 2.03 years) with best corrected visual acuity (BCVA) of 20/20 or better and an absence of systemic and/or ocular conditions that could potentially result in CS reduction were examined under binocular conditions.

The Bailey-Lovie high contrast chart was used to qualify subjects as meeting the necessary 20/20 visual acuity measure. Subjects were randomly assigned to either an ascending or descending testing method. If assigned to the descending method, the target was shown at a visible contrast level and then decreased at set intervals until the subject responded incorrectly. If assigned to the ascending method, the target was presented at a contrast level at which it could not be identified and then increased until the subject responded correctly. The order in which the different sized targets were presented was randomized, as well as which type of target would be presented first, Sloan letters or SWG. The end point of each method was recorded for all Sloan letter sizes and SWG CPD. For every target, contrast thresholds were obtained twice in a single visit. The Sloan letter targets were presented at the following sizes: 20/200, 20/100, 20/50, 20/40 and 20/30. The SWG targets were presented at the following CPD: 3, 6, 12, 15, and 20, which correspond to the Sloan letter sizes. Contrast threshold values were converted to logCS units. A comparison of the mean logCS values from corresponding sizes of Sloan letters and SWG was made.

RESULTS

- There was no statistically significant difference in the CS thresholds measured between the ascending and descending methods ($p>0.05$).
- Mean logCS was not statistically significantly different between two trials in all targets.
- Mean logCS followed a similar pattern of changes at different target sizes: logCS decreased as the target size decreased.
- Mean logCS values were statistically significantly different, greater in gratings compared to letters, in all target sizes ($p<0.001$) except 20/200 and 3cpd ($p=0.03$) and 20/30 and 20cpd ($p=0.05$).

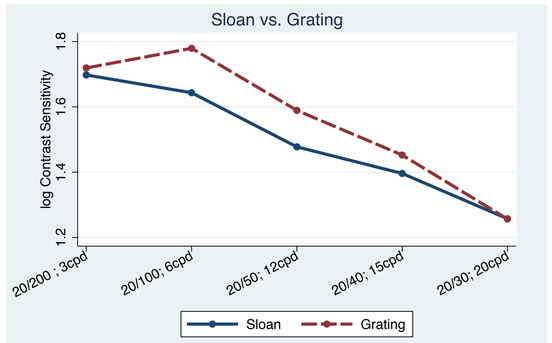

FIGURE 1: *This plot shows the log of the contrast sensitivity of the Harris Sloan letter contrast sensitivity testing at five different size letters along with the log of contrast sensitivity of the Harris Sine Wave Grating at five different cycles per degree. As per prior publications the visual acuity measures were correlated to specific sine wave cycles per degree (example: 20/200 = 3 cycles per degree (cpd) and 20/50 = 12 cpd).*

CONCLUSION

It is necessary to examine whether the SWG and Sloan letter targets as presented in the Harris test provide comparable results. In 2006, McAnany and Alexander found that CS as measured with these different targets may not be equivalent. They demonstrated that the broad spatial frequency content inherent in letter targets alters the measurement of contrast sensitivity.[3] Our results appear to confirm those findings. They suggest that measuring CS using a grating target may be more accurate than when using a letter target. The established human contrast sensitivity function indicates peak sensitivity at 4 CPD with decreasing sensitivity at higher and lower spatial frequencies.[4] The contrast sensitivity function obtained with SWG targets on the Harris test is more consistent with this standard than that obtained with letter targets.

Additionally, the results suggest testing reliability. There was no significant difference between two trials at all sizes and with both types of target. This is significant due to the questionable reliability of other CS tests that employ similar testing methodology.[5] More investigation is needed to confirm these findings, but these preliminary results are promising. It shows the potential to incorporate this electronic application in a routine eye exam to gain additional insight into visual function.

REFERENCES

1. Schwartz, S. H. (2010). *Visual perception: A clinical orientation*. New York: McGraw-Hill Medical Pub. Division.
2. Henderson, S., Kim, J., Harris, P. (2015) Validation Study of New LCD-Based Contrast Sensitivity Testing Method. Poster presentation at Optometry's Meeting, Seattle, Washington, June 2015
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4. Campbell, F. W., & Robson, J. G. (1968). Application of Fourier analysis to the visibility of gratings. *The Journal of Physiology*, 197(3), 551-566.
5. Reeves, B. C., & HILL, A. (1991). Vistech VCTS 6500 Charts-Within-and Between-Session Reliability. *Optometry & Vision Science*, 68(9), 728-737.

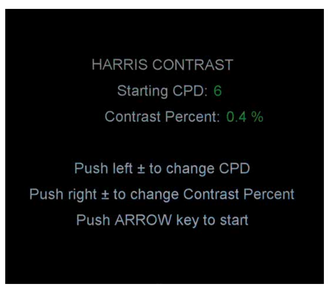

FIGURE 2: *This shows the opening screen to begin the sine wave grating testing. Both the starting cycles per degree (CPD) and the contrast percent can be altered before beginning the testing.*

FIGURE 3: *The above three pictures show the progression from 8 to 17 to 20 percent contrast with three different orientations of the lines being shown.*

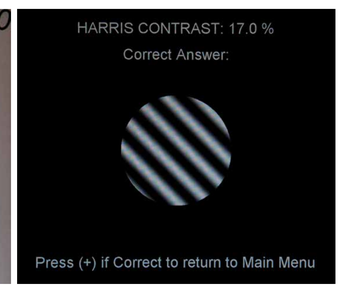

FIGURE 4: *This figure shows the ending screen which tells the operator the orientation and the percentage contrast of the last correct answer given by the subject.*

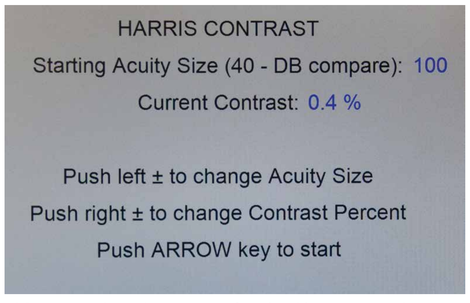

FIGURE 5: *Opening screen for the Sloan Letter Contrast Sensitivity test. Both the size of the letter to be displayed and the beginning contrast levels can be here.*

FIGURE 6: *This shows a 20/100 letter at 5.6% of contrast.*

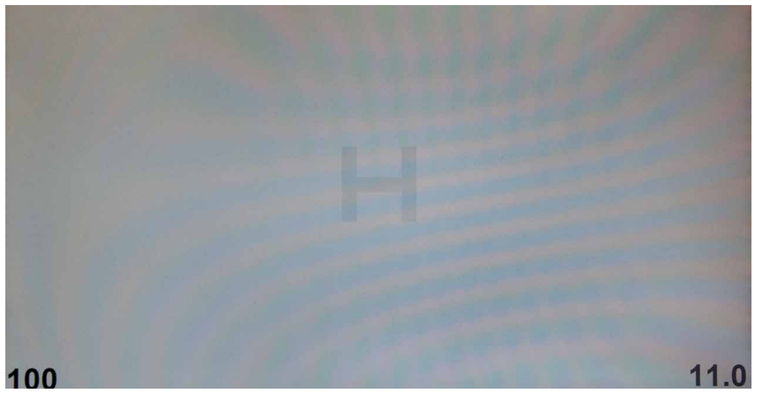

FIGURE 7: *This shows a 20/100 letter at 11.0% of contrast.*

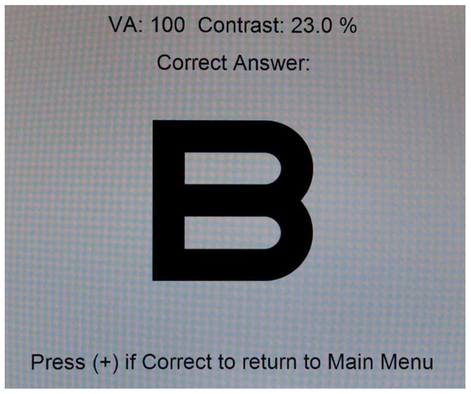

FIGURE 8: *This is the final screen showing the last correct response to the examiner with the contrast level obtained.*