Evaluating Sinusoidal Luminance Gratings as A New Electronic Visual Acuity Test on A Tablet Device

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Introduction

1. Visual acuity (VA) tests can estimate one's visual function[1].
2. There are 2 categories of VA tests: Letter types (Sloan Letters, Tumbling E) and Image types (Kay Picture, Grating).
3. Among these tests, (Sinusoidal Luminance) Grating is suggested as the most satisfactory visual tests[2] with high reliability and accuracy.
4. Therefore, Grating newly developed as an electronic VA test (ASTEROID) on a tablet device, for people to test their eyesight at home easily without healthcare professionals.
5. To ensure Grating's validity and reliability, the researcher compare its testing result with Kay Pictures, Sloan Letter and Tumbling E that performed by the same subject.

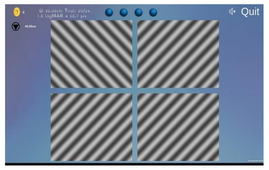


Figure 1: Sinusoidal Luminance Grating (a pattern of black and white stripes) visual test on tablet.

Aim

- To compare the test-retest reliability of Grating, Tumbling E and Sloan Letter, with Kay Pictures.
- To determine which VA tests result (Grating/Sloan Letter/Tumbling E) is the closest (high agreement) to the VA test used clinically (Kay Picture).

Methodology

1. The subject sits 40cm from a tablet (ASTEROID app version 1.0.41) with his left eye covered in an ambient lighting room.
2. The subject performs all 3 VA tests (Grating, Tumbling E and Sloan Letter installed in app) with habitual vision. Then, repeat those tests without glasses (if the subject wear glasses in the habit) or wearing a blurred lab spectacles for degraded vision.
3. The subject is instructed to choose the odd out of 4 squares 20 times for every VA tests (e.g. different orientation of Grating, Figure 1). His eyesight score computed by the app is recorded.
4. His electronic score is compared with his clinical VA test (Kay Picture, 40 cm, habitual vision).

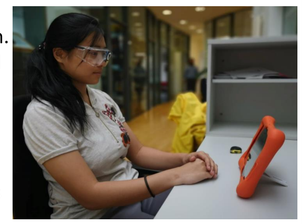
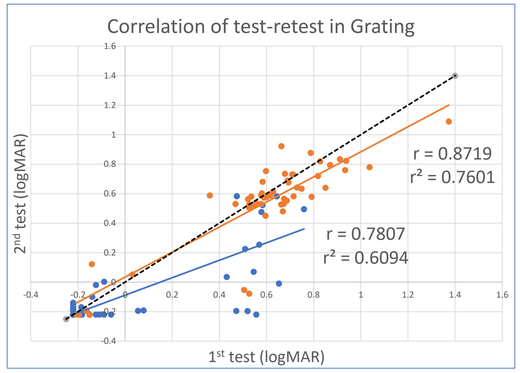
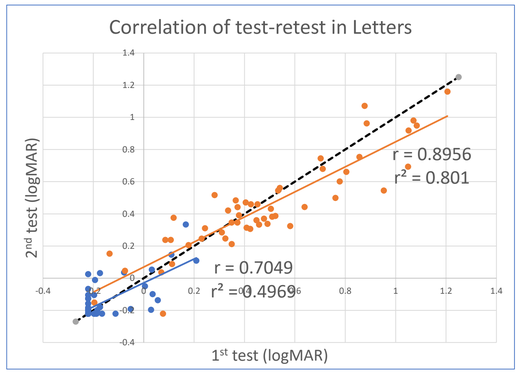


Figure 2: A subject with blurred lab spectacles is sitting 40cm in front of a tablet.

Results





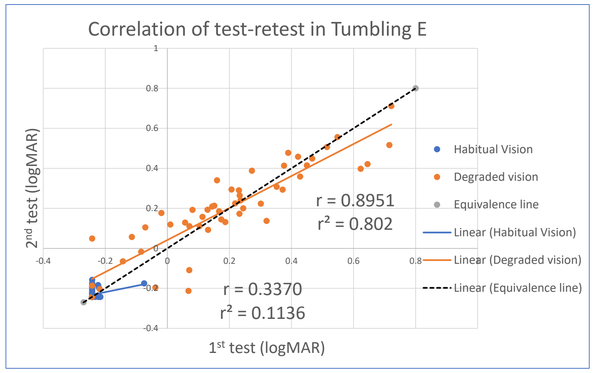
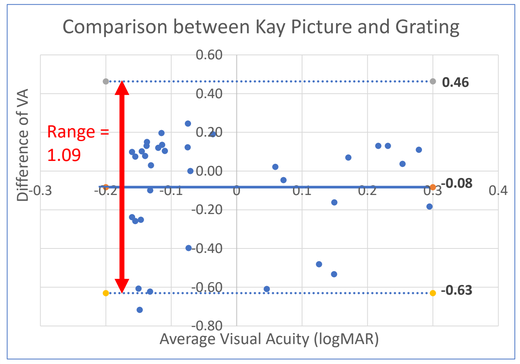
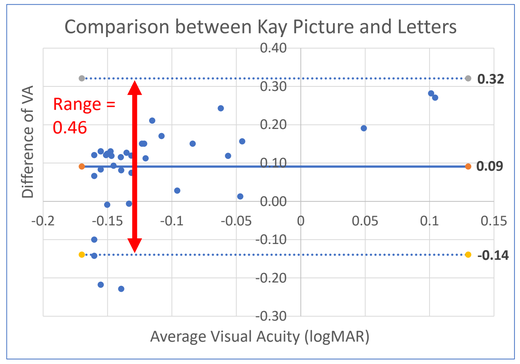


Figure 3: Correlation of 1st test and 2nd test (retest) in 3 different visual acuity tests





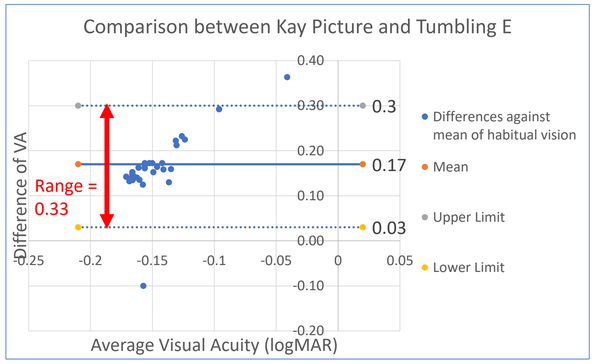


Figure 4: Bland-Altman plot of the difference of VA between Kay Picture and (D) Grating, (E) Letters, (F) Tumbling E in 34 adults, 40cm distance from Kay Picture Chart or tablet device with habitual vision plotted against the average VA of two types of visual tests.

Discussion

1. Equivalence line ($R/R^2 = 1$) represents ideal result which there is no difference between test and retest. R means correlation coefficient while R^2 is a measure of how close is the data collected to the equivalence line. In Figure 3, **Grating has the lowest R^2** than Letters and Tumbling E in measuring degraded vision (orange line), which indicates that the eyesight reading obtained through Grating in 2nd test has the biggest difference from 1st test. Although Grating has the best R^2, 0.6094 in measuring habitual vision among three electronic VA tests, it is still lower than the Kay Picture (R^2=0.7345, data provided by a colleague, Ying Xin Wong). Therefore, it is concluded that **Grating has poor test-retest reliability**.
2. All results of test-retest reliability is not ideally as the subjects also tends to score better visual acuity in retest due to practice effect. Therefore, the repetition should be conducted with spaced time (e.g. more than one day).
3. In Figure 4, Bland-Altman plot used to quantify bias (mean difference and its 95% confidence interval) between Kay Picture and Grating, Letters, Tumbling E[3].Grating has the widest range among 3 visual tests which indicates that the eyesight reading measured by Electronic Grating test can differ by 1.09 from Kay Pictures Chart, which is really a big difference. **Grating has bias in measuring habitual vision and it has poor agreement with Kay Picture**.
4. The Grating also has luminance artifacts at their borders. The subject can figure out the direction of the Grating (stripes) easier at the corner of the square instead of looking at the center[4].

Conclusion

1. Sinusoidal Luminance Grating has the highest test-retest reliability for habitual vision among all 3 three electronic VA tests, but the lowest for degraded vision.
2. Tumbling E result is the closest to the Kay Pictures, while Sinusoidal Luminance Grating has the lowest agreement with Kay Pictures.
3. More modification is needed on the electronic sinusoidal luminance grating visual test before conducting another validation experiment.

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