Validating the new version of stereoacuity digital test

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Introduction

Stereopsis is the perception of depth arising from the combined visual information from both eyes, and it is measured as stereoacuity which is the smallest detectable depth difference that can be seen in binocular vision.[1,2] Stereoacuity is best assessed with test such as random-dot stereograms (RDS) which provides no monocular cues to depth[3]. A new digital stereotest, known as ASTEROID, which uses RDS technique on an autostereoscopic 3D tablet was developed by a group of researchers in Newcastle University for use in eye clinic. However, the stereoacuity of ASTEROID is approximately 1.5 times higher than a similar stereotest on stereoscopic 3D TV or on Randot Preschool stereotests.[4] This might be due to the large chunky dots used in ASTEROID. To evaluate this, the research team has come up with a new version of ASTEROID which adopts smaller dots and at higher density. This paper will look at the performance of new version of ASTEROID and compare it with the old version.

Hypothesis

The new version (small dots) of ASTEROID will produce a better stereoacuity (lower score) than the old version (large dots) of ASTEROID.

Methodology

45 adult subjects aged 18 to 80 were recruited from the students of Newcastle University and Newcastle University Institute of Neuroscience Research Volunteer pool. Each subject is required to complete both version of the ASTEROID test twice. The sequence could be 1) old, new, old, new or 2) new, old, new, old. Some subjects are tested twice

The ASTEROID test consists of 24 trials of 4-alternative forced-choice. There are 4 panels of dynamic random dots shown on the screen for each trial and one of these 4 panels has a square floating in depth that can only be seen with 2 eyes together. The subject will identify the different one and touch the respective panel on the screen and the test will move on to the next trial.

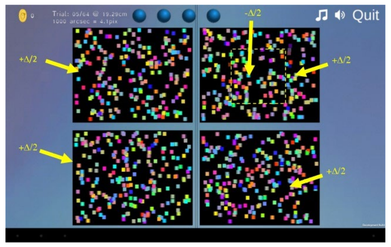


Figure 1 showing the screen of ASTEROID stereoacuity test.

The results were analyzed and interpreted to find:

1) Test-retest reliability of the 2 versions of ASTEROID
2) Comparison between stereoacuity of 2 versions of ASTEROID

Results

1) Test-retest reliability of the 2 versions of ASTEROID

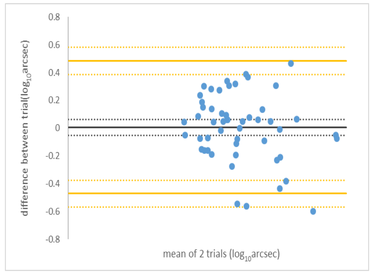
A) Scatter plot of first test in **new** version against second test in **new** version

Correlation coefficient=0.763521

B) Scatter plot of first test in **old** version against second test in **old** version

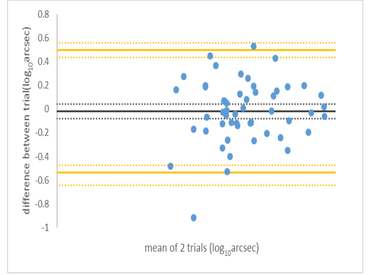
Correlation coefficient=0.744036

C) Bland-Altman plot of **new** version



	Unit (log_{10}arcsec)
mean difference	0.006326
standard deviation	0.243553
95% limit of agreement	±0.477364
Range	0.954729

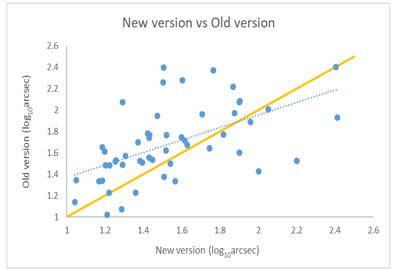
D) Bland-Altman plot of **old** version



	Unit (log_{10}arcsec)
mean difference	-0.01876
standard deviation	0.263128
95% limit of agreement	±0.515731
Range	1.031462

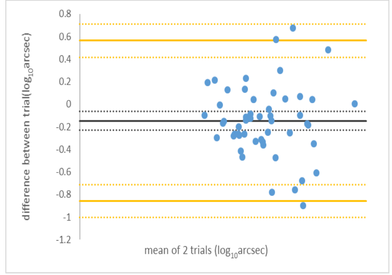
2) Comparison between stereoacuity of 2 versions of ASTEROID

A) Scatter plot of mean of 2 tests of **new** version against mean of 2 tests of **old** version



Correlation coefficient= 0.557075

B) Bland-Altman plot of **new** version against **old** version



	Unit (log_{10}arcsec)
Mean difference	-0.14583
Standard deviation	0.36193
95% limit of agreement	±0.709383
Range	1.418766

1) The graphs above show that both version of ASTEROID test have good repeatability (i.e. the subjects results would not fluctuate greatly on repeated tests.) This can be seen by the high correlation between two tests in both version. It can be seen from the Bland-Altman plots that there is no any obvious grouping of data above or below the mean difference line (black line) and this suggest that the difference in 2 trials might be just due to random fluctuation instead of systematic error such as practice effect. The 95% limits of agreement for both versions of ASTEROID are considered narrow, with old version being slightly larger than the new version.

2) The graphs shows the comparison of stereoacuity between 2 versions of ASTEROID. The 2 sets of data are moderately correlated and has a correlation coefficient of 0.557075. It can be clearly seen that from graph A, most of the data (36 out of 52 sets of data) are clustered above the identity line. This suggests that for most measurement, the old version of ASTEROID has got a higher score (i.e. worse stereo-threshold) than the new version of ASTEROID and this is in accordance with our hypothesis. The low value of paired sample 1 tailed t-test suggests that this difference is indeed significant. The Bland-Altman analysis shows a very small value of mean difference which is only -0.1458 log10arcsec and the 95% limits of agreement which is ±0.7094 log10arcsec (a factor of 5.12).

Discussion

1) Test-retest reliability

Both versions of ASTEROID stereotests show similar stereoacuity for the two tasks performed with only little fluctuation between the 2 readings. The variation in stereoacuity in the two tests are free of interobserver effect as every subject is measured by the same examiner. Therefore, it is thought that the fluctuation of the results is due to the ¼ chance of guessing the right image.

2) Comparison between stereo-threshold of 2 versions of ASTEROID

The data clearly shows that stereoacuity measured is affected by the dot size and density of the dots. It is thought that the smaller dots could make the border of the square clearer thus making the perception of stereo edge easier. This view is supported by research by G Liat and EB Harold, in which almost doubled stereoacuity is scored when random dots density is lower.[5] The justification was increase in spacing between element at lower density decreases the usefulness as a reference for relative disparity judgments.

Conclusion

Both versions of ASTEROID have shown good repeatability, with the new version perform slightly better than the old one. The data also shows that the old version of ASTEROID generally has a higher score (i.e. worse stereoacuity) than the new version.

Reference

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