

Comparing
Square Wave Grating Acuity Testing
to Snellen Acuity Testing
in non presbyopic adults.

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Abstract:

We compared monocular unaided acuities of non-prebyopic adults, utilizing square wave gratings and Snellen at both distance and near. The acuity correlated well at distance (.86 correlation coefficient) with the exception of the highly myopic eyes. However, the T-value (10.42) indicates the acuities are significantly different, especially with the highly myopic eyes. At near, using the Teller Acuity Cards, the correlation coefficient was just below the acceptable level. The T-value (5.76) for near also indicates the acuities were dissimilar between these two testing methods. This variability of measured acuities may be due to the 'edge artifact' of the square wave gratings and the several differences between the two different types of testing methods.

There are several different methods utilized to measure infant acuity such as optokinetic nystagmus, visual evoked cortical potentials, broken wheel acuity cards, Allen figures, tumbling E, forced choice preferential looking, and various other tests. This paper will concentrate on comparing forced choice preferential looking with Snellen acuity on adult test subjects at distance and near.

For infants and young children, assessment of acuity depends on an adults interpretation of non-verbal responses. Until recently, behavioral testing of acuity after infancy was not possible before about age 2.5 to 3 years, when children could be tested with the Allen Picture Cards or a similar test. However, with the preferential looking procedures infants can be tested at a younger age in a short periods of time.

The preferential looking technique depends upon the fact that "infants spontaneously fixate on various high contrast patterns such as bold stripes for longer periods of time than they fixate on homogeneous fields. A potential measure of grating acuity is the finest striped field in which the infant will consistently fixate".¹

The preferential looking method has "been recognized as a useful measure of vision in children with ocular disorders".² In addition, "it has a potential as a screening device for pre-verbal children at risk for amblyopia"³ as well as being effective at identifying children with binocular visual problems.

However, it is questionable as to whether preferential looking can be useful as a directional accurate measure of infant acuity. There have been several studies, but researchers are divided as to the accuracy of the PL technique. One study reports the preferential looking technique underestimating acuity due to the negative preference dip: "infants psychometric functions in preferential looking experiments are non-monotonic; that is with increasing

¹ Teller D. et al. Visual acuity for vertical and diagonal gratings in human infants. *Vision Res.* Vol. 14 , pp 1433-1439 1974.

² Mayer D. Hanson R. and Fulton A. Preferential looking acuity obtained with a staircase procedure in pediatric patients. *Invest. Ophthalmol. vis. sci.* 23:538-543, 1982.

³ Mayer D., Hansen R., and Fulton A. 1982

spatial frequency such functions drop from high levels of preference for the grating (approximately 100%) to below 50%, before finally asymptoting at 50% preference".⁴ This movement is called the negative preference dip....."performance significantly below chance implies discrimination of the grating and blank fields, and hence, the detection of the grating." ⁵ Because they ignored preferences significantly below 50%, they concluded that the acuity was "systematically underestimated."⁶

Teller has shown that children do not look at finer stripes in preference to a gray field as stripe width decreases.⁷ Also another study has shown that infant visual acuity is underestimated because near threshold gratings are not preferentially fixated. It is argued that for most infants a blank field is preferred over a grating for some spatial frequencies. This is another potential source for underestimation of acuity. It is also argued that the Teller preferential looking procedure does not address this reversed preference.⁸ In addition to this, children tend to lose interest due to decreased attention span as testing continues. Therefore, as the infant acuity threshold is reaching the child's attention span, it is at it's lowest point. This tends to underestimate the acuity as well.

However, there are some studies to support the fact that "grating acuity scores overestimate acuities obtained by using conventional measurements, particularly in patients with foveal abnormalities."⁹ In addition it has been demonstrated that the acuity cards contain an 'edge artifact' that is responsible for

⁴ Held R., Gwiazda J., Brill S., Mohindra I., and Wolf J. Infant visual acuity is underestimated because near threshold gratings are not preferentially fixated. Vision Res. 19, 1377-1399, 1973

⁵ Held R., Gwiazda J., Brill S., Mohindra I., and Wolf J. Vision Res. 1973

⁶ Held R., Gwiazda J., Brill S., Mohindra I., and Wolf J. Vision Res. 1973

⁷ Teller D. 1974

⁸ Held R. Gwiazda., Brill S., Mohindra I., and Wolf J. 1973

⁹ Mayer D.L. et. al. Grating and recognition acuities of pediatric patients. Ophthalmol. Visual Sci., 1151-1157, Dec. 1978

overestimating acuity in communicative subjects between 17 and 30 years of age.¹⁰

In comparing Snellen acuity to grating acuity, the effects of blur need to be more carefully examined. As gratings decrease in size they may approach a pure resolution limited task. Thus blur should, theoretically, affect acuity in a straightforward manner.¹¹ Blur decreases contrast sensitivity for gratings, but this blur does not compare to the effects of dioptric blur for Snellen acuity. Snellen is resolution dependant, but it is also dependant on recognition of the letters and, even possibly, hyperacuity to detect the positions and orientations of the lines on the letters.

In one study in which the effects of dioptric blur on Snellen and grating acuity were compared, it was found that "grating acuity was effected very little by dioptric blur"¹² However, Snellen acuity was markedly reduced by blur with an almost linear relation between letter size and blur."¹³ This difference in the effects of blur can be another contributory factor to the potential variability in acuity results between these two types of acuity tests.

Method:

APPARATUS:

The distance set up consisted of a black and white square wave grating apparatus with two apertures 41.2cm apart. The square wave gratings were projected from two projectors of equal luminance behind the apertures. The gratings ranged from 2.66 mm/cycle to 53.19 mm/cycle (20/15-20/300 Snellen equivalence. The preferential looking apparatuses were set 39.5cm from the

¹⁰ Robinson J., Moseley M.J., and Fielder A.R., Grating acuity cards: spurious resolution and the "edge artifact". Clin. Vis. Sci. 3:285,1988.

¹¹ Thom F., and Schwartz F. Effects of dioptric blur on Snellen and Grating Acuity. Optom. and Vis. Sci. Vol 67, No.1, pp.3-7,1990.

¹² Thom F., and Schwartz F. 1990

¹³ Thom F., and Schwartz F. 1990

distance Snellen chart and the subjects were tested 20 feet from this distance set up. For the near acuity testing, Teller acuity cards were utilized at 38cm ranging from 28.5 cycles/degree to 2.4 cycles/degree. The near Snellen Acuity card was utilized at 40 cm. It is important to note that not all Snellen equivalents were able to be incorporated into the square wave grating acuities, particularly for the Teller cards due to the availability of only certain specific square wave gratings at the 38cm distance.

SUBJECTS AND PROCEDURE:

Eighteen non prebyopic subjects were selected at Ferris State University, their ages ranged from 19 to 29 years of age, and there was an approximate equal distribution of males and females. The specific selection was based upon their refractive error in order to provide a relatively normal distribution sample. Unaided spherical equivalents of subjects with less than 1D if cylinder: 1) High Myopes (<4.00D) 13.5%, 2) Medium Myopes (>-1.00 to -4.00D) 18.9%, 3) Medium Hyperopes (>+2.00 to +6.00D) 10.8%, 4) Low Myopes (0 to -1.00D) 24.3%, 5) Low Hyperopes (0 to +2.00D) 32.4%.

Subjects were tested monocularly at both distance and near. The preferential looking was forced choice response with subjects required to correctly identify 75% of Snellen letters on a specific acuity level to be identified as having that acuity.

RESULTS AND DISCUSSION:

Results of this research were subjected to a T-test statistical probability measure. In this test forum, the test results are viewed as probabilities of similar responses being given between the two testing methods. Upon gaining this T-test probability figure, a level of significance is derived to show the probability of similarity in curve fit. The higher the test figure, the lower the probability of gaining the same results by using the alternate testing method.

Distance square wave and Snellen correlated well with a .86 correlation coefficient. However, the T-test results indicate that the acuities of the two different testing methods to be significantly different (T-value = 10.42, probability for T-test 0.00). This is most prominently noted for the highly myopic eyes (T-value = 18.31,

probability for T-test 0.00). Preferential looking acuity for these subjects were considerably reduced compared to Snellen. Although the acuities were very dissimilar, the acuities of distance square wave grating testing and Snellen of high myopic eyes correlated well (.638). Measuring the correlation of preferential looking versus Snellen without the high myopes reduced the correlation coefficient by 51%.

The fact that these two tests correlate well indicates that one acuity testing method may predict the acuity of the other testing method, even though the acuities are significantly different. It is important to note that using one testing method as an indicator of the other is not necessarily a practical measure.

This difference in measured acuity may be somewhat attributed to the edge artifact. Many subjects reported being able to see the edge of the square wave gratings on this preferential looking apparatus, but could not distinguish the central portion of the square wave grating. This is noted most obviously with the high myopic subjects because it is with this test group that has the highest amount of optical blur with unaided acuity for distance. Therefore, subjects utilized the edge more frequently to determine their field preference.

Near Snellen acuity also correlated fairly well to near Teller Acuity Cards (.68 correlation coefficient). The T-test value for near testing also indicates the Teller Acuity Cards and Snellen acuities are not comparable (T-value = 5.76, probability for T-test 0.00). Again at near, it was expressed by several subjects that the edges of the square wave gratings (particularly for the higher frequency cards) were obvious, whereas the center of the square wave gratings were again not visible. This edge artifact, which is very hard to mask, most likely contributed to the overestimation of acuity.

Another possible contributing factor to the variability on acuity results may be due to the fact that preferential looking technique is a resolution limited task with a 50% chance of a correct response. In contrast, Snellen requires recognition as well as resolution to determine the correct letter. Both methods require a 75% correct response for the subject to be considered at that specific acuity level, but use different means to reach that endpoint.

In addition to this, in this study, we utilized college aged adults as compared to the infants upon which the test is generally utilized. Adult subjects tend to observe the square wave grating at a much higher cognitive level than the infants that are fixating on patterns. These two very different ways to choose the correct forced-choice response also contribute to the variability in testing results.

Overall, the preferential looking technique has been proven to be a good screening device for infant acuity and acuity of non-communicative adults. It has also been shown to detect amblyopia and binocular vision problems in children. However, in this particular test group of non-presbyopic adult subjects, our test results indicate acuities, particularly in high myopes at distance testing, significantly reduced with this grating method compared to Snellen. It is evident that, compared to Snellen, square wave grating testing has not been proven to be an accurate measure of adult acuity at distance or near in this particular test.

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