PURPOSE

A Dutch Ophthalmologist, Herman Snellen, developed a standardized vision-testing chart more than 150 years ago that has been adopted worldwide with minor changes in concept and form. The computer age has opened many doors to new ways to measure visual acuity and visual performance but they are generally only computerized graphic images or portions of standard charts.

Inventor Allan Hytowitz designed a new dynamic target called the “Dyop” (short for Dynamic Optotype), which is a rotating, segmented optotype. The Dyop may be varied by diameter (angular arc width or arc areas), contrast, or color at constant or reversed rotational velocities to assess acuity threshold as a functional measure of minimum perceptible resolution. Results of this study could alter and improve how visual acuity is measured.

METHODS

162 subjects were seated in a standard examination chair and were assessed for visual acuity thresholds by viewing, on a fully randomized basis, two different acuity charts with a series of test conditions. Testing was done at a full 20 foot testing distance with the only room lighting generated from the LCD monitors used by the computerized testing systems. Threshold acuities were assessed for each of the following test conditions for all subjects:

- Sloan Letters
  - Refraction uncorrected
  - Refraction corrected
- Refraction corrected with: +2.00 lens; +3.00 lens; +4.00 lens
- Dyop Optotype
  - Refraction uncorrected
  - Refraction corrected
  - Refraction corrected with: +2.00 lens; +3.00 lens; +4.00 lens

Dyop acuity values were collected in arc minutes for purposes of this testing that were equal to the visual angle of the outer diameter of the circular optotype. These were presented to the subjects on a Chart2020® system (Shenemier Medical, Johannesburg, SA). Sloan letter acuity was measured on a Smart System® (M&S Technologies, Niles IL) using a new stair-step methodology, the Harris Visual Acuity Protocol, that features much finer graded steps than standard acuity lines.

WHAT IS A DYOP?

A Dyop is a segmented, circular figure composed of equally spaced segments that rotates at constant velocity. The Dyop is smoothly scaled from large to small until a novel endpoint, not experienced with historical acuity assessments, is reported. The rotation appears to stop when the acuity threshold is reached. The continuous battle (and associated frustrations) to push assessments, is reported. The rotation appears to stop when the acuity threshold is reached. The precise Dyop diameter changes at constant or reversed rotational velocities to assess acuity threshold as a functional measure of minimum perceptible resolution. Results of this study could alter and improve how visual acuity is measured.

In this study, a high contrast black and white Dyop target was used with the rotating figure appearing on 50% grey background. While contrast and color can also be varied for other visual function assessments, it was not a variable in this study. The structure of the zooming Dyop allows very rapid closure to and bracketing of the threshold size. Dyops may be a universal measure as they are cultural, literacy, and language independent.

The calibrated Dyop image uses a combination of image diameter (angular arc width), segment/gap stroke width, percentage of total width (angular arc area), rotation speed (RPM), contrast, color, and the pixelized strobic photoreceptor refresh rate to create an acuity threshold as an indicator for the measurement of visual acuity. As photoreceptors require change in stimulus to evoke an excitatory response from the photoreceptors, a kinetic optotype may more favorably match the nature of the visual response mechanism than a static optotype in which small eye motions help tease out the visual response. Additionally, unlike static images, which get increasingly blurry as they get smaller or further away, the rotation of Dyop images stops being detectable at a discrete point as the acuity threshold is reached. The precise Dyop diameter serves as an indicator of acuity based upon the angular arc width and viewing distance.

Figure 2 shows three Dyop optotypes on the screen with the largest on the left and the smallest on the right. Each would be turning in a random direction. In this configuration the subject reports which direction the middle Dyop is turning. As threshold is reached, in the largest Dyop (left), motion is seen, the yellow highlighted middle sized Dyop appears to stop moving or “twinkles”, and the right smallest Dyop clearly no motion is reported. In typical acuity threshold ranges, the left could be 20/14, the middle 20/13, and right 20/12.

RESULTS

There was a strong linear relationship between Sloan and Dyop acuity measures (Pearson r=.94, p< .001). In a single predictor model, the Dyop measure explained 89% of the variance in Sloan acuity. An interaction model relaxing the assumption of common slopes by testing condition indicated a significant measure X condition interaction (p=.004), and explained over 91% of the variance in Sloan acuity. Optimal conversion algorithms between Dyop and Sloan measures were developed via regression models.

Figure 3 is a plot of the log of the Sloan VA/20 against the log of the Dyop size in arc minutes. The linear Pearson correlation is very strong (r=.95; p< .001). This is in all conditions for all 162 subjects. Figure 4 shows the breakout for each condition.

The best fit for this in a simple linear form is:

$$\log(\text{Sloan LogMAR}) = -1.557 + 2.204\log(\text{Dyop})$$

Figure 4 show the scatter plots for each of the separate conditions. Correlations were significant to the p < .001 level in all conditions. Pearson correlations for each condition were: Rx Corrected r=.54, +2 blur r=.72, +3 blur r=.72, +4 blur r=.63, overall pooled r=.94.
**VARIABILITY, EFFICIENCY, EASE OF USE**

We noticed that with the Dyop we were able to get to endpoints very quickly, and when plotted, the data showed a marked reduction in variability with far more linearity. At times, when looking at averaged data the richness of clinical observations made gets obfuscated. Figures 4 and 5 show the Log plots for all of the individual subjects by test condition.

**DISCUSSION**

We noticed in Figure 5 some outlier lines which seemed to indicate that going from one level of blur to another, where we expected a decrease in visual acuity, that we actually got an increase. At the lowest part of the graph, a green line can be seen shifting downward (better visual acuity) towards +2.00 on the X-axis. Based on this finding we looked at individual sets of data to determine how often this occurred.

In the Sloan VA testing, 31 of the 162 subjects had these anomalies. 15 of them had a recording of a better level of visual acuity at the +4.00 level of blur than at +3.00. 12 of them had a recording of a better level of visual acuity at +3.00 blur over the +2.00 blur. Four subjects had the same exact level of visual acuity recorded at two different levels of blur, either at both the +2.00 and +3.00 or the +3.00 and +4.00 level of blur.

With the Dyop there were only three of 162 such instances. With one subject the visual acuity recorded was the same with the +3.00 and +4.00 blur. With one subject it was better with the +4.00 vs. the +3.00 blur and with one other subject it was better at the +3.00 than at the +2.00 level.

**CONCLUSIONS**

The Dyop is a novel method of measuring visual acuity that is strongly associated with, and may offer an improvement in assessment of visual acuity compared to historical methods. In addition to a strong correlation with traditional methods, the Dyop was reported to be advantageous due to the speed at which the threshold endpoint is defined, finer acuity granularity compared to the typically used acuity ‘line’ steps, and ease of endpoint identification by subjects.

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