How Snellen Computerized Vision Testing is Adding to Myopia

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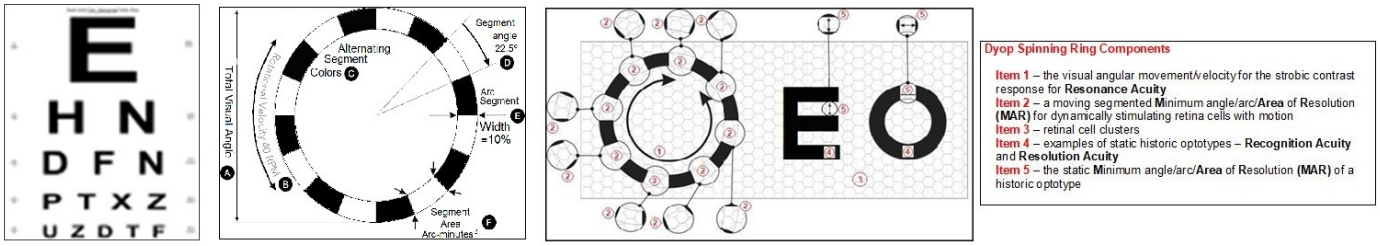
Abstract

Vision is an autonomic and dynamic process inherent in all animals because the world we see is dynamic, rather than static. Our eyes are **biological machines** which help us survive by enabling us to **automatically detect motion, distance, and colors** so that we can see predators and food and eat rather than be eaten. By vision being autonomic most of us don't have to think about the images we see properly being in focus.

Visual acuity is the term used to describe **the clarity of what we see**. A **refraction** is the process of **using special lenses** to measure the **optical variables** of **sphere, cylinder, and axis** which go into creating eyeglasses and contact lenses and compensate for "less than perfect" vision. "Traditional" vision tests use **static letters or symbols** as standard targets for measuring vision [1]. The flaw **in those static measurement systems** is that they typically measure **only two dimensions** using the **height** of the visual target and the **viewing distance** to that target. Instead, the world we see (the "**real world**") is a **fifth dimensional process** consisting of **height, width, colors, distance, and time**.

A **Dyop®** (pronounced "**di-op**" and short for a special type of **dy**namic **op**totype) is a **calibrated** segmented spinning ring visual target (aka, optotype) **which helps doctors (and you) test the clarity of your vision**.[2] A **Dyop** provides a **strobic stimulus** to the **photoreceptors in the central rear area of the retinal** of your eye called the **fovea.** The smallest angular diameter of a Dyop which can be detected as spinning is the **acuity endpoint** [3]. When a Dyop becomes sufficiently small as to its angular diameter, the contrasting gaps become too small to be detected as spinning and the Dyop has a **sub-acuity diameter.** Comparative refractions have documented that **a Dyop is up to six times more precise than Snellen testing**, **up to eight times more consistent, and up to more than three times as efficient for acuity and refraction measurement**. Dyop color permutations can measure **acuity in color** as a diagnostic and potential for therapy for symptoms of dyslexia, migraines, and epilepsy. Dyop testing does not require patient literacy so that it can be **used to measure acuity in children and infants as young as 14 weeks of age** [4]. A Dyop's precision, adaptability for color-based testing, and suitability for both clinical and remote use make it a compelling alternative to static optotypes, with potential applications in detecting dyslexia, early-stage glaucoma, and other vision-related conditions [5].



A Dyop's acuity endpoint corresponds to a **White-gap stimulus area** (**Minimum Area of Resolution**, **MAR**) of 0.54 arcminutes squared, compared to the traditional Snellen **MAR** of 1.0 arcminutes squared. Comparative refraction analysis revealed that the ratio of the Dyop ring's diameter to the viewing distance is linear, unlike the logarithmic relationship used in Snellen and Sloan charts that underpins the LogMAR system indicating that LogMAR is as much a measure of the bloated Snellen stimulus as it is of acuity. However, comparative Snellen/Sloan refractions also consistently showed an excess of approximately –0.50 diopters of **minus power** compared to Dyop measurements. This systematic overminus with Snellen/Sloan likely contributes to visual fatigue, reduced comfort, diminished literacy outcomes, and the **Global Epidemic of Myopia** [6].

Keywords: Snellen chart, Dynamic optotype, Visual acuity, Dyop test, Log MAR, Motion detection, Vision screening.

Introduction

The **Snellen chart**, introduced by Herman Snellen in 1862, has been the standard for gauging visual acuity for over 160 years, and was "canonized" in 1984 as the global "standard" for clinical acuity measurement by the **Consilium Ophthalmologicum Universale**.[7] It presents static, high-contrast letters in decreasing sizes and relies on identifying the smallest one a person can read. It was simple, familiar, and deeply embedded in clinical practice. Its strength is in its simplicity, but that is also its greatest weakness by measuring acuity in "only" 0.25 diopter increments and requiring familiarity with European style letters and/or symbols as part of **Recognition Acuity**.

From research observations and literature, we learned that letter-based tests like Snellen measure more than light refraction. They measure literacy, memory, and familiarity with the alphabet [8]. Someone might "pass" simply because they recognized the symbols, not because of clear vision. This limitation is especially important with children, non-literate populations, and individuals with neurological differences such as dyslexia or visual stress [9]. Another flaw experienced firsthand: Snellen's reliance on static images and bright white backgrounds can disguise subtle refractive errors, worsen glare sensitivity, and do not assess temporal visual processing, which is essential for real-world visual tasks.

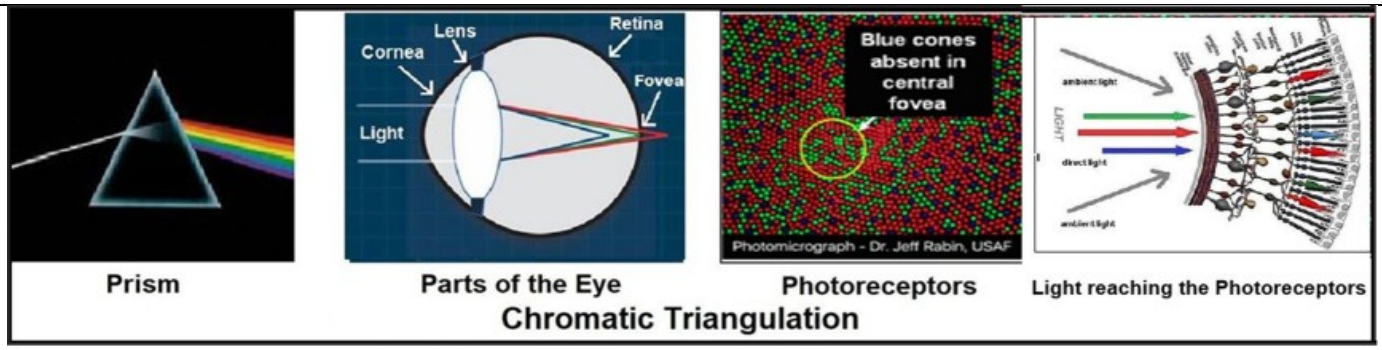
That is an advantage of the **Dyop** concept of a spinning segmented ring where the acuity question is: *"Can you see the motion of the ring?"* Unlike letter charts, the Dyop shifts the test from literacy-dependent **Recognition Acuity** to the pure visual function of **Resolution Acuity**, engaging the visual system's spatial-temporal processing and minimizing cognitive bias. This paper will explore the inherent flaws of the Snellen chart which, despite its historical importance, is not an accurate or equitable measure of vision, and how a Dyop's dynamic approach could offer precise, efficient, and accessible visual assessments for diverse populations [10, 11].

Vision Self-Tests verify the mechanics of vision http://www.dyop.net/documents/Acuity-Self-Tests.pdf

- **Chromatic Triangulation demonstration**: Close one eye and look around. You will still perceive depth perception and relative distance to your visual target, suggesting acuity is regulated by the retina and **not** the brain as a binocular image.
- **Excess minus power test**: If you wear glasses, push them about 0.5 inches (or 1 cm) forward away from your face. If the text appears clearer, your lenses are likely overminused by 0.25 to 0.50 diopters, enough to reduce cognition and potentially reduce your IQ by 10 points or more.
- **Overstimulation test**: Stare at a White light bulb briefly, then close your eyes. You'll likely see a White afterimage. The same hyper-stimulus from computer-based Snellen tests using bright White contrast damages the foveal photoreceptors' perception and refresh rate.

What Regulates Acuity

For vision to be effective and efficient, it needs to be autonomic (so that we are unaware of that process). However, acuity is NOT regulated by the brain. As light goes through the **cornea and lens,** it is bent (refracted) so that **Blue** is focused in **FRONT of the retina, Green** is focused **ON the retina,** and **Red** is focused **BEHIND the retina. (See the diagram below.) Acuity is regulated by the relative focal depths and intensity of those three colors as they are perceived by the color sensitive cone-shaped photoreceptors in the fovea area at the back of your eye.**



https://www.dyop.net/documents/Acuity_Mechanics.pdf

An Audio Tuning Fork provides an auditory tone used to calibrate sounds based on the disparities in the wavelength of sounds. A Dyop functions as a Visual Tuning Fork where the focal depths of the colors Red, Green, and Blue comprise the components of visual images and are used to adjust the shape of the biological lens based on the relative focal depths of those colors. The strobic stimulus of a segmented spinning Dyop ring functions to refresh the stimulus of the Red, Green, and Blue sensitive fovea photoreceptors to regulate the shape of the lens and the focal depth of the image in relation to the retina. The increased precision (6x), increased consistency (8x), and increased efficiency (3x) of a Dyop is from the disparity of the contrasting Dyop stimulus gap (0.54 arcminute squared) versus the bloated and irregular Snellen stimulus gap (1.0 arcminute squared).

Dyop Commercial Potential

The global vision care market exceeds $75 billion annually, with over 2.5 billion people annually requiring visual correction. The Snellen test limitations, combined with the Dyop test's increased precision, create a clear commercial opportunity for disruption. At a modest $20/month for a professional subscription, the Cloud Dyop should generate millions in annual recurring revenue, while improving diagnostic outcomes worldwide. Moreover, its educational and humanitarian potential is substantial. With literacy-independent formats and infant screening capability, Dyop testing supports equitable access to eye care in low-resource settings.

Vision Science Basics When Using Dyop Tests

Understanding vision principles is crucial for appreciating how the Dyop test offers a more accurate and reliable measure of visual acuity and refractions compared to traditional ("Snellen") methods. The unique properties of the Dyop stimulus, combined with its ability to engage the foveal photoreceptors optimally, are instrumental in advancing vision science and improving patient outcomes.

1. **The Snellen test**, as a benchmark for acuity and refractions, is **inherently imprecise, inconsistent, and inefficient** due to its reliance on **Recognition Acuity, Cultural bias,** and identifying (or guessing) three of the five letters per line in the final steps of the test [9]. Nearing 20/20 acuity (or 6/6 in the metric world), the rows become five letters (or shapes) of decreasing size. Except we don't "see" the letters or "see" the **Black** areas. Instead, we perceive the irregular **White areas** surrounding the culturally dependent **Black shapes** (e.g., letters) which **do NOT stimulate your fovea photoreceptors**. With Snellen testing (or other static shapes) we see only the surrounding **White** areas, which are perceived as a combination of the pixelized colors of Red, **Green**, and **Blue** light stimuli.
2. However, the strobic stimulus of a spinning segmented **Black/White** ring optotype (now called a Dyop® - pronounced "di-op" and short for **dy**namic **op**totype) can be used as a much more precise visual target for acuity and refractions than the Snellen "standard." The optimal Dyop rotation speed is 40 rpm, with an optimum 10% ring stroke width which creates a **specific gap size (0.54 arcminute squared)** and motion crucial to acuity precision [9]. The **Snellen gap AREA** (such as the spacing in the "E" or the gap in the "C") is **1.0 arcminute squared** and nearly twice the size of the Dyop's stimulus gap **AREA,** indicating that the **logarithmic** ratio of the Snellen optotype height versus diopters of blur **(LogMAR)** may be more due to the Snellen "**gap area"** being twice the size as the actual **M**inimum **AREA** of **R**esolution (**MAR**) than Snellen being an accurate measure of acuity.
3. The **Dyop optimum rotation rate** (40 rpm) matches the optimum photoreceptor refresh rate (0.33 arcminutes squared per second), thus contributing to the strobic Dyop optotypes being significantly more precise than static optotypes [10]. That optimal Dyop fovea refresh rate allows the photoreceptors to relay their signals to layer of **neuroganglia** cells in front of the retina. [11] The neuroganglia cells then send the composite Red, **Green**, and **Blue** signal from about 20 fovea photoreceptors to the cilia surrounding the biological lens to controls the shape of the lens while a composite signal from about 100 fovea photoreceptors is transmitted to the brain (via optic nerve fibers) where that image is stored and interpreted.
4. Contrary to conventional belief, **acuity is NOT regulated by the brain** but rather acuity is regulated by the foveal photoreceptors through a process called **Chromatic Triangulation** which allows the focal depth colors of **Red**, **Green**, and **Blue** and the response of the color receptive photoreceptors in the fovea to adjust the shape of the lens with the benchmark being the optimum focal dept of green being ON the retina [12, 13].
5. **Computerized vision testing** utilizing (static) **White gaps** such as with Snellen letters or shapes for **Recognition Acuity** depletes the foveal photoreceptors' response and refresh rate, promoting a preference for excess minus power in prescriptions. That in turn contributes to eyeball elongation and increasing myopia. **It is likely NOT a coincidence that**

the Global Epidemic of Myopia began about 40 years ago at about the same time as the use of computerized Snellen testing. A Dyop test, with **White** gaps and **Black** segments on a **Gray** background, demonstrates how, as the **Black/White** Dyop shrinks in diameter, the **White** area becomes too small to sufficiently stimulate the fovea, causing the motion perception to vanish. At a **sub-acuity threshold**, the spinning Dyop ring appears to be a static undifferentiated **Gray** ring [14].

Dyop Test Formats

Current Dyop Test formats:

1. The online **Cloud Dyop** (at www.cloud-dyop.com) **does NOT need computer installation and** has the "standard" Dyop Clinical precision of 0.04 diopters increments.

2. The **Windows Dyop requires installation on a Windows computer,** http://www.dyop.net/documents/Dyop_Application_Request.pdf
   The Windows Dyop test has the full assortment of Dyop test formats including the 0.04 diopter increment **Clinical test**, a **Children's test** using preferential looking Dyop test with two Dyops alternating as static or spinning, an **Infant Test** with ONE spinning Dyop which alternates its location within two target rings, a **Color Screening test** with a panoply of hexadecimal adjustable colors options to diagnose visual stress and contrast sensitivity, a **Precise Dyop test** using 0.02 diopter increments, and an **Adjustable Oval Dyop** which allows for the determination of a refraction without the need for a phoropter or Trial Lens Frame kit.
   https://www.dyop.net/documents/Measuring_Visual_Cylinder_and_Axis_with_a_Dyop.pdf
   https://www.dyop.net/documents/Subjective_Measurement_of_Cylinder_Powe_and_Axis.pdf

3. **Online Dyop Screening tests for Acuity, Color Stress, and Cognition** (primarily for use by teachers and parents).
   www.dyopacuity.com for **a five-foot** viewing distance,
   https://www.dyop.net/documents/Dyop_acuity_screening-10f.gif for a **ten-foot** viewing distance,
   www.coloracuity.com for a **five-foot** viewing distance,
   https://www.dyop.net/documents/BlueGreenScreening_10f.gif for **a ten-foot** viewing distance,
   www.dyopcognition.com

4. An **iPad Dyop test** which uses an iPhone as an image controller.
   https://apps.apple.com/us/app/dyop-vision-test/id1300193573

Key Advantages of the Cloud Dyop:

1. **Scalable Global Access** – Works on any device with an internet connection, allowing eye care professionals in both developed and emerging markets to conduct standardized, high-precision visual assessments (+/- 0.04 diopter increments) when there is internet access.

2. **Low-Cost Screening for Mass Deployment** – The Cloud Dyop's rapid test cycle (<10 seconds per trial) and **Resolution Acuity** literacy independence make it ideal for community screening and telehealth programs for adults and children.

3. **Planned Enhancements and Upgrades include:**

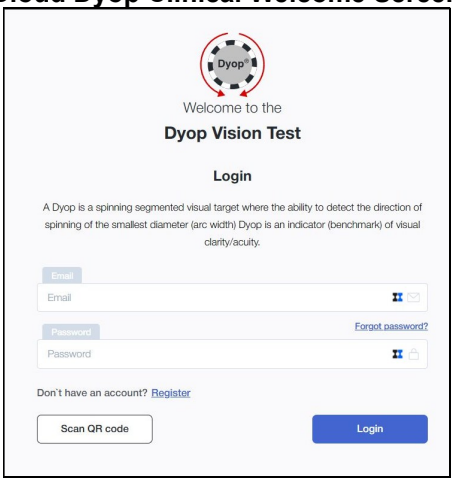
- Child and Infant Dyop formats with wider-separated targets for use with eye-tracking systems
  https://www.dyop.net/documents/Dyop_Infant_Acuity_Measurement_Poster.pdf
- Color-based Dyop testing for dyslexia, migraine, epilepsy, and glaucoma screening
  www.coloracuity.com
- The **Adjustable Oval Dyop**, enabling remote refractions without the need for a phoropter or trial lenses.
  https://www.dyop.net/documents/Measuring_Visual_Cylinder_and_Axis_with_a_Dyop.pdf
  https://www.dyop.net/documents/Subjective_Measurement_of_Cylinder_Powe_and_Axis.pdf
- **Integration Potential** – The platform can be seamlessly embedded into existing tele-optometry systems, school screening programs, and government health initiatives.

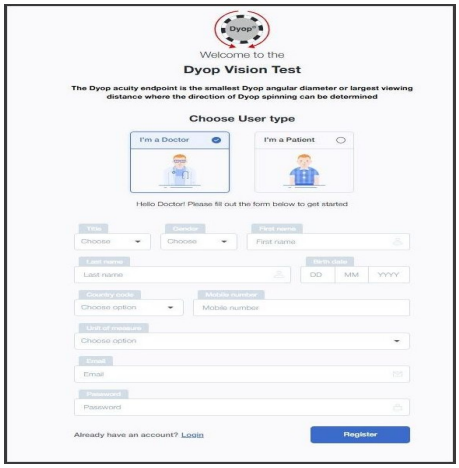
The Dyop Cloud Professional Acuity Test

www.Cloud-Dyop.com

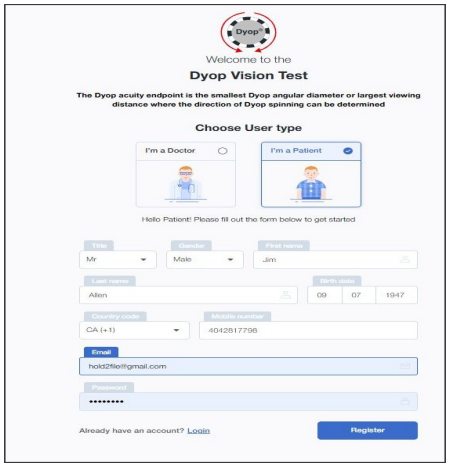
A Cloud version of the Dyop test is available at www.Cloud-Dyop.com at no charge and with no need for having to do a computer installation. The Cloud Dyop has the same precision, consistency, efficiency and accuracy (+/- 0.04 diopters) as the Windows Dyop Clinical test.

Cloud Dyop Clinical Welcome Screen

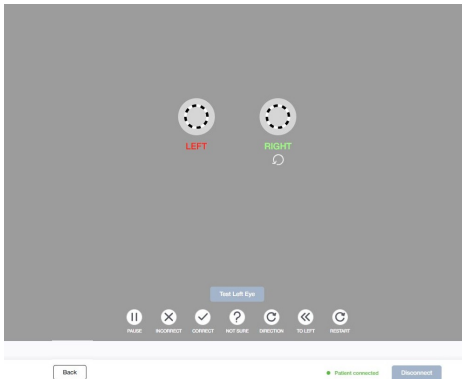




Doctor Registration



Patient Registration



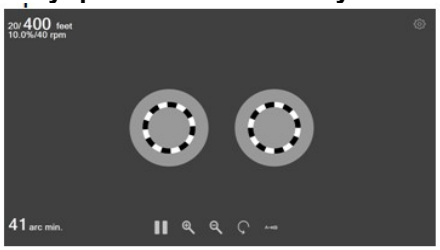
Doctor Response Screen

Patient Response Screen

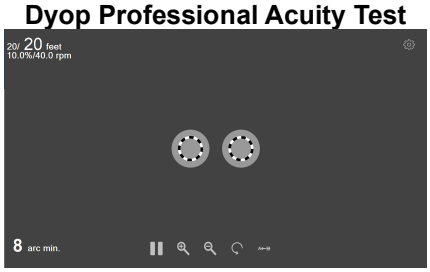
Dyop Clinical Windows Professional Test

http://www.dyop.net/documents/Dyop_Application_Request.pdf

Dyop Professional Acuity Test



Dyop Professional Acuity Test

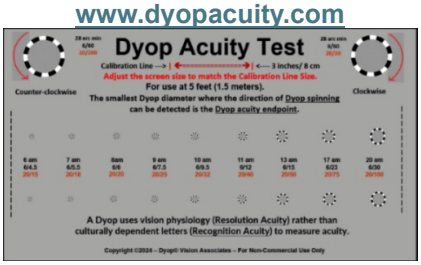


Dyop Professional Children's Test

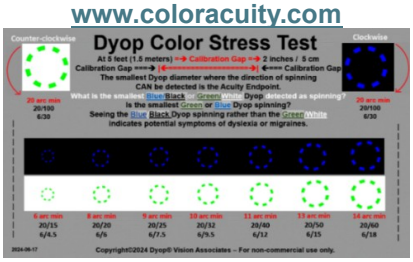
Dyop Professional Infant Test

Dyop_Online Screening_Tests

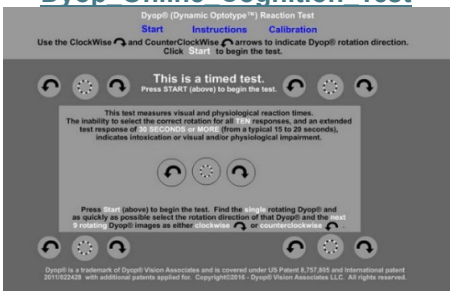
Online
Dyop Acuity Screening Test
www.dyopacuity.com



Online
Dyop Visual Stress Test
www.coloracuity.com



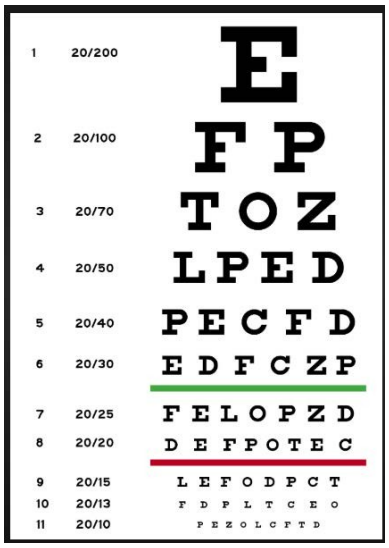
Dyop_Online_Cognition_Test



Dyop_Online_Cognition_Test

Early identification of children with reading difficulties, especially those from difficult home environments, can prevent social and educational marginalization. In extreme cases, these unmet challenges can contribute to school violence. The **Dyop Visual stress color screening (dyslexia) test** may help identify students needing intervention and support [15]. The timed **Cognition Screening Test** (Dyop_Online_Cognition_Test) may enable early diagnosis of cognition difficulties associated with symptoms of Alzheimer's, Parkinson's, PTSD, marijuana intoxication, or concussion injuries.

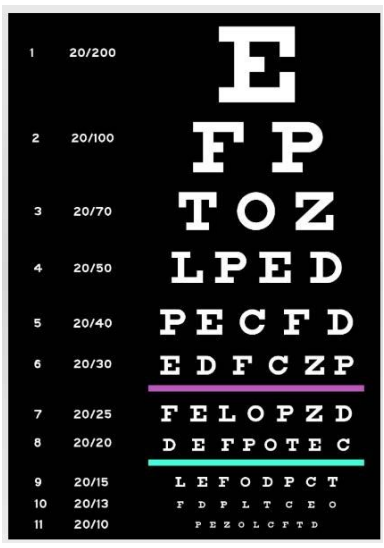
Fifteen years after the initial Dyop discovery, the discovery of cataracts in both eyes explained the loss of cognition and depression during the previous three years [16]. However, after the cataracts were removed, there remained an associated experience of headaches and mental fatigue while looking at a computer monitor. Reducing the screen brightness and contrast from 100% to 50% eliminated those headache symptoms, highlighting the damage caused by the high-contrast emitted White background screens inherent in Snellen testing. Without the “curse" of cataracts, we may never have uncovered the blessings of understanding Snellen's 21st-century harm as a factor in the **Global Epidemic of Myopia**. **It now is stunning to realize how "good a guess” it was to set the Black letters with a White background to a 50% brightness and 50% contrast level as a comparative cognition test. For a Black letter on a White background, the maximum cognition of the Black letters is at 50% brightness/contrast.**



Normal Snellen –
Black letters on White background

% Contrast	Max Viewing Distance- Feet	Max Viewing Distance- Feet
%Brightness	Snellen White Background	Snellen Black Background
100	20	27
90	21	27
80	22	27
70	22	37
60	23	26
50	24	24
40	21	22
30	20	20
20	16	18

Maximum Viewing Letter Comprehension Versus percent brightness/contrast



Reverse Snellen –
White letters on Black background

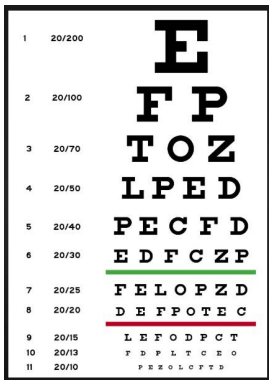
NOTE: This needs to be Academically validated as to the **changes in Contrast** versus the measured acuity values for **BOTH “Snellen options**.”

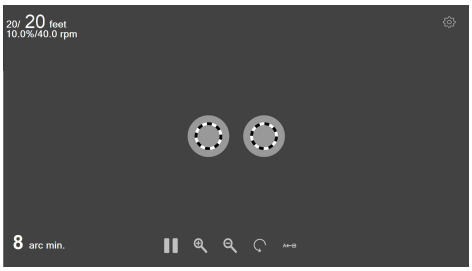
While innovative in 1862, **Snellen's chart overlooks the fact that we perceive the white spaces creating and shaping the black letters**, **rather than the letters themselves**. The **Dyop light Gray target ring background** for a was chosen so that as the spinning Dyop ring shrinks, the Black/White contrast of the gaps and segments fades into a seemingly Gray static ring. The **Dyop dark Gray test stage** was chosen so as to NOT distract from the spinning Black/White spinning Dyop rings. But it turns out that the **White screen backgrounds of modern computerized Snellen tests** play a significant role in overminusing prescriptions, inducing myopia, and likely contributing to the **Global Epidemic of Myopia** [6].

The original White areas on the **original printed paper Snellen test** are visible due to **reflected light**, however, the White areas on modern computer screens (versus the Black letters) are from emitted light which burns out the response of the fovea photoreceptors. Photoreceptors do NOT respond to Black areas so that what you see as Black is the stimulus from the adjacent non-Black areas. The stimulus of the emitted light is like briefly looking at a light bulb which leaves a residual image when you close your eyes. That **modern-day emitted light visual damage** from computerized Snellen testing often comprises as much as 90% of the screen area.

However, the main impediment with Snellen type testing isn't just its imprecision, letter inconsistency, inefficiency, cognition requirement, or temporary visual fatigue from static targets burning out the dynamic response of the fovea. While the Snellen/Dyop “optotype disparity” may explain why the Dyop test is six times more precise, eight times more consistent, and three times more efficient than Snellen testing, the “optotype disparity” does NOT explain the Snellen/Dyop consistent refraction disparity which has Snellen testing generating about 0.50 diopters of excess minus power versus Dyop testing. That high contrast unintentionally induces excess minus power due to the “white” also leads

to myopia as an outdated technology due to the lack of awareness by the optical profession of the disparity caused by replacing reflected light with computer-generated emitted light.





Without the “curse” of cataracts, we may never have realized the explanation for Snellen's 21st-century harm as to the consistent addition of 0.50 diopters of minus power for a Snellen refraction versus a Dyop refraction. The high contrast White areas versus the Black letters on a computer screen were unintentionally inducing myopia as an outdated technology due to the lack of awareness of the disparity of the effect of white emitted light from the computer monitor by the optical profession.

At present we have simplified the Dyop explanation for non-scientists [20].
The www.dyop.org website offers complimentary screening tests primarily for use by teachers and parents:

- A 10-second **online acuity screening test for viewing at 5 feet = www.dyopacuity.com**
- A 5-second **online dyslexia screening test for viewing at 5 feet = www.coloracuity.com**
- A timed **online cognition screening test = www.dyopcognition.com**

Anticipated Cloud-Dyop enhancements:
Due to its increased precision, increased consistency, increased efficiency, and lack of the need for computer hardware installation, it is expected that the Cloud-Dyop (www.cloud-dyop.com) will become the dominant global standard for acuity and refraction measurement. The Clinical application of the Cloud-Dyop will eventually incorporate a paywall for Professional use patients but the consumer, teacher, and parent applications for the Cloud-Dyop test will remain free to use. That per patient Professional fee will be sufficiently low that it will be attractive for use by Eye Care Professionals with a potential market of 100 million refractions per year in the United States and the additional 2 billion global refractions per year.
We are expecting that the software developer (Inmost.pro) will be able to modify the Cloud Dyop test for optimum Clinical use (with +/- 0.04 diopter clinical precision) **to include the following format enhancements:**

- A wider separation for the Dyop target rings (moving from a central pair of rings to 1/4 and 3/4 screen separation target ring locations) which will also facilitate use of an **eye tracking system for the combined Adult/Child format.**
- An **Infant Acuity format** with two target rings **(but only ONE spinning Dyop ring alternating** at the alternating 1/4 and 3/4 screen width **target ring locations)** taking advantage of the inherent infant preference for motion detection.
  https://www.dyop.net/documents/Dyop_Infant_Acuity_Measurement_Poster.pdf
- **Color acuity testing** for potential diagnosis of symptoms of dyslexia, migraines, and epilepsy.
- A single **Adjustable Oval Dyop** which can be used to measure acuity on a two-dimensional surface [21, 22].

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