The Origin of the Dyop®

Allan Hytowitz
(N=1)
Helping the world see more clearly, one person at a time.

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Allan’s Mystery

Allan’s Day Job - Annual Sales

Year

Production $1,000


0 50 100 150 200 250

Blind Period
Allan’s Discovery

Allan’s Day Job - Annual Sales

with OS RX

- Progressive Lenses
- Computer Lenses

Year

Production $1,000

Lens Diopters
Allan’s Discovery

Inherent Vision Loss with **Progressive Lenses**

Dyslexic Areas caused blurry and distorted vision and almost four years of functional blindness
Allan’s Discovery

Allan’s view with Computer Lenses
Clear and “coherent”

Only smart people can read this.

The phenomenal power of the human mind, according to a research at Cambridge University, is that it doesn’t matter in what order the letters in a word are, the only important thing is that the first and last letter be in the right place. The rest can be a total mess and you can still read it without a problem. This is because the human mind does not read every letter by itself, but the word as a whole.

Allan’s view with Computer Lenses
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Allan’s Discovery

Allan’s view with **Progressive Lenses**
Unclear and “incoherent” from tunnel vision

Only smart people can read this.

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Allan’s Original Vision Test Device

Spinning LED’s turned blurry in the peripheral areas
“Rotating Segmented Circles”

Early attempts to create a rotating image
“Rotating Segmented Circles”

Early attempts to create a rotating image (100 hours later)
“Rotating Segmented Circles”

Allan’s view - Single Vision Lenses

All of the circles appear to be IN focus.

Each number represents 2 arc degrees when viewed at 28 inches on a 19” monitor.
“Rotating Segmented Circles”

Allan’s view - Progressive Vision Lenses

Only the primary vision area circles appear to be IN focus.
Each number represents 2 arc degrees when viewed at 28 inches on a 19” monitor.
"Rotating Segmented Circles"

Allan’s view - Single Vision Lenses

As you MOVE ONLY YOUR EYE(S) the dyslexic areas become blurry with color distortion

How big should the “Rotating Segmented Circles” be?
“Rotating Segmented Circles”

“How big should the circles be?”

Rotation detection of the larger images as the distance gets greater.

You either see the rotation or you don’t.
“Rotating Segmented Circles”

Welcome to Vision Science

The Dyop® concept is actually ONLY (geekie) high school math and science

Circle = 360 degrees = 21,600 arc minutes
1 degree = 60 arc minutes
Static images = 5 arc minutes
Static diameters = 8.89 mm at 20 feet (6 m)
Dyop® images = 7.6 arc minutes
Dyop® diameter = 13.5 mm at 20 feet (6 m)
“Rotating Segmented Circles”

Dynamic Optotype = Dyop®

Variables:
Dyop® color = White vs. Black
Dyop® background = Black vs. White
Dyop® stroke width = 2.5% stroke width to 20% stroke width?
Dyop® sectors = 2 sectors to 16 sectors?
Dyop® 20/20 diameter = 12 mm to 16 mm
Dyop® shape = dots vs. segments vs. triangles?
**“Rotating Segmented Circles”**

**Stroke Width versus Perception Distance**

**Dyop® Threshold Image versus Perception Distance as of 2009-10-27**

Stroke widths (& gap widths) of 2.5%, 3.75%, and 5%

8 segments per Dyops® with 22.5 degree gap height @ 40 rpm

White segments on a Black Background

<table>
<thead>
<tr>
<th>Threshold Image diameter</th>
<th>Perception Distance 2.5% stroke width</th>
<th>Perception Distance 3.75% stroke width</th>
<th>Perception Distance 5% stroke width</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (* see Note)</td>
<td>PD - feet*</td>
<td>PD - feet*</td>
<td>PD - feet*</td>
</tr>
<tr>
<td>18</td>
<td>24</td>
<td>25</td>
<td>26</td>
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<td>17.25</td>
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<td>14.25</td>
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<td>13.5</td>
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<td>11.8125</td>
<td>16</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>
“Rotating Segmented Circles”

**Stroke Width versus Angular Arc Width**

Varying the Dyop stroke width (and stimulus area) and the rotation rate indicated that the "optimum" Dyop had a **10% stroke width**, an angular width of **7.6 arc minutes**, and a rotation rate of **40 rpm**.
“Rotating Segmented Circles”

Stroke Width versus Angular Arc Width

Note that it is easier to detect the gap/segments of a static Dyop (zero rpm) than a Dyop at 20 rpm and 40 rpm. This disparity indicates that static image fixation increases the gap/segment visibility of static optotypes, thus increasing the tendency for an over-minused refraction.
How We See

“Allan’s Pixel Theory of Acuity”

Our eyes developed to detect motion, distance, and color

Emitted (computerized) light increases perception

4 layers of Neural Cells

Epithelium

Light

Photoreceptors

100 Photoreceptors

1 Optic Nerve Fiber
How We See

“Allan’s Pixel Theory of Acuity”

Stiles-Crawford Effect increases the perception of emitted light due to photoreceptors being at the BACK of the retina.

4 layers of Neural Cells

Epithelium

Light

Photoreceptors

100 Photoreceptors

1 Optic Nerve Fiber
How We See

“Allan’s Pixel Theory of Acuity”
The eye is akin to a digital camera

[Diagram of a digital camera's components, including a lens, light sensor, analog-to-digital converter, memory, and microprocessor.]
How We See

“Allan’s Pixel Theory of Acuity”
The eye is akin to a digital camera

Dyop® stroke width versus photoreceptor stimulus path

20/20 Snellen = 6/6 metric = 7.6 arc minutes angular width
= 0.76 arc minute gap/segment width or
0.54 arc minutes squared or about 20 photoreceptors
How We See

“Allan’s Pixel Theory of Acuity”
Dyop® strobic stimulus of the photoreceptors

Item 1 – visual angular velocity or strobic contrast response
Item 2 – a moving segment visual arc-area dynamically stimulating retina cells with motion
Item 3 – retinal cells
Item 4 – an example of a static historical optotype
Item 5 – a static minimum angle of resolution of a historical optotype
How We See

“Allan’s Pixel Theory of Acuity”
The eye is akin to a biological computer

Types of unique neurons in the retina

Dyop® strobic stimulus of the photoreceptors detects motion and color
How We See In Color

Allan’s view - **Progressive Lenses**

Peripheral color distortion reduces comprehension

Left ✅ Normal colors

Dyslexic Area

Astigmatic color shift

→ Right

Dyslexic Area

Astigmatic color shift
How We See In Color

If we see in color…
what colors do we see?

60 acuity endpoint color/contrast combinations.
How We See In Color

If we see in color…
what colors do we see?

<table>
<thead>
<tr>
<th>G1/G1</th>
<th>White/G1</th>
<th>Gray2</th>
<th>Gray3</th>
<th>Gray4</th>
<th>Gray5</th>
<th>Black/G6</th>
<th>Amber</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
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<tbody>
<tr>
<td>g6_g1</td>
<td>g6_g1_g2</td>
<td>g6_g1_g3</td>
<td>g6_g1_g4</td>
<td>g6_g5</td>
<td>g1_g6</td>
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<td>g1_g6_green</td>
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<tr>
<td>G3/G1</td>
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<tr>
<td>Green</td>
<td>g6_g1</td>
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<tr>
<td>Blue</td>
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<td>30</td>
<td>23</td>
<td>27</td>
</tr>
</tbody>
</table>

60 color acuity endpoints with the endpoint distances in feet. The optimum (minimum) combination is Black/White-on-Gray.
How We See In Color

The colors of **Blue**, **Green**, and **Red** are bent by the lens. **Green** is focused on the retina for more **stable near vision**. **Red** is focused on the retina for a more **stable distance image**.

**Green Focused Vision (GFV)**
- 50% **Red** and 45% **Green** photoreceptors

**Red Focused Vision (RFV)**
- 75% **Red** and 20% **Green** photoreceptors
How We See In Color

“Green Focused Vision” has 50% Red, 45% Green, and 5% Blue photoreceptors.

“Red Focused Vision” has 75% Red, 20% Green, and 5% Blue photoreceptors (“slow readers” or dyslexics).

Rough estimate of photoreceptor distribution*:

<table>
<thead>
<tr>
<th>Vision Type</th>
<th>% Red (L)</th>
<th>% Green (M)</th>
<th>% Blue (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green-Focused</td>
<td>50</td>
<td>45</td>
<td>5</td>
</tr>
<tr>
<td>Red-Focused</td>
<td>75</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

* Dr. Chris Chase, Western University, Pomona, CA
Dyop® Color/Dyslexia Screening

Visual stress is from an unstable near image.

Types of Visual Dyslexia

- Blurry Effect
- Halo Effect
- Shaky Effect
- Swirl Effect
- Rivers Effect
- Seasaw Effect
- Washout Effect
- Overlapping Writing
How We See In Color

The ratio of Red, Green, and Blue photoreceptors is directly related to their color acuity endpoints.

Note: smaller arc width indicates better acuity

<table>
<thead>
<tr>
<th>Dyop</th>
<th>Myope - 6 Subjects - Non-dyslexic - Balanced Red Photoreceptors Color Acuity Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Basic Acuity</td>
</tr>
<tr>
<td>Arc Width</td>
<td>8</td>
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<tr>
<td>Snellen</td>
<td>20/20</td>
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<table>
<thead>
<tr>
<th>Dyop</th>
<th>Myope - 3 Subjects - Dyslexic - Higher Red Photoreceptor Ratio Color Acuity Comparison</th>
</tr>
</thead>
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<th>Color-Blind Hyperope - 3 Subjects - Higher Red Photoreceptor Ratio Color Acuity Comparison</th>
</tr>
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<tbody>
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<tr>
<td>Snellen</td>
<td>20/20</td>
</tr>
</tbody>
</table>
Dyop® Color/Dyslexia Screening

Which color/contrast can you see most clearly?
Color preference directly related to visual stress.

Green-on-White or Blue-on-Black
Dyop® Color/Dyslexia Screening

“Green-Focused Vision” sees rotation of a Green Dyop® on a White background better than a Blue Dyop® on a Black background.

“Red-Focused Vision” sees rotation of a Blue Dyop® on a Black background better than a Green Dyop® on a White background.

Green-on-White  or  Blue-on-Black
Dyop® Color/Dyslexia Screening

Preliminary Research
“Only” 73% correlation to diagnosed symptoms of dyslexia
Dyop® Vision Standards

SCO Acuity Data - 2013 and 2014
2013 = 150 Subjects
2014 = 162 Subjects

Acuity Study – Dr. Paul Harris, SCO
Increased Dyop® precision and reduced over-minus
Dyop® Vision Standards

### Reduced Dyop® Variance

<table>
<thead>
<tr>
<th>Study Condition</th>
<th>Variance</th>
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</thead>
<tbody>
<tr>
<td>Projected Sloan (2013)</td>
<td>0.282</td>
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<tr>
<td>Sloan letters (2013)</td>
<td>0.233</td>
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<tr>
<td>Dyop - Doublet (2014)</td>
<td>0.035</td>
</tr>
</tbody>
</table>

Table 1 summarizes the variance in the test conditions over the two years of the study.

*Acuity Study - Dr. Paul Harris, SCO*
Dyop® Vision Standards

- Eliminates cultural and educational testing bias
- Resolution acuity rather than cultural recognition acuity
- Standards based upon physiology rather than comprehension
- Increased precision (up to 6x)
- Faster administration (up to 2x)
- Improves low vision testing
- Infant / non-literate testing relevant to adults
- Precise color perception testing
- Simple software configuration
- Does NOT need FDA approval
12,000 Hours Later…
The Dyop® Revolution

United States Patent
Hytowitz

ANIMATED IMAGE VISION TEST

Inventor: Allan N Hytowitz, Alpharetta, GA (US)

Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

Appl. No.: 12/583,225
Filed: Aug. 17, 2009

Prior Publication Data

Int. Cl.
A61B 3/02 (2006.01)

U.S. CL. 351/239

Field of Classification Search 351/239
See application file for complete search history.

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6,592,222 B1 * 7/2003 Stern et al. 351/239

Patent No.: US 8,083,353 B2
Date of Patent: Dec. 27, 2011

ABSTRACT

Animated image vision tests take advantage of the ability of our eyes to detect both distance and motion. Moving images, such as rotating segmented circles, let the eyes detect motion as to the size, distance, and rotation direction of that moving image. That motion detection is much more precise than the interpretation of multiple static letters or static images. Using rotating images for vision testing rather than static images creates an acuity test more accurate than current tests, a test that is faster to use, and a test that doesn’t require the ability to read.

1 Claim, 17 Drawing Sheets
18,000 Hours Later…

George Woo & Allan

Ian Bailey & Allan

Gus Colenbrander, Paul Harris, & Allan

Mark Bullimore & Allan

Jeff Rabin & Allan

Dyop Flash Prototype
The Dyop® Revolution

A Dyop is a revolutionary 21st century way of measuring vision.

Twenty-first century electronic images use pixels which change color and intensity to create the images we see. The photoreceptors of the eye function much like those pixels. Your brain uses the photoreceptor response to create vision and bring that image into focus. When the moving gaps and segments of a Dyop (short for dynamic optotype) get too small, their strobic stimulus is too small for the pixel effect to be detected by the photoreceptors of the eye. The smallest Dyop gaps and segments detected as moving create an acuity and refraction endpoint.

Faster and more accurate acuity and refractions.

Unlike static image vision tests, such as a logMAR or Snellen chart which get increasingly blurry as they get smaller, the rotation of the Dyop appears to stop when the acuity threshold is reached. A Dyop is a segmented, circular figure composed of equally spaced segments that rotates at constant velocity. A patient is presented with 2 Dyops, side by side, one moving and one static and is asked to determine the direction of the spinning Dyop.

What is detected is not so much the motion of the gaps and segments, but that strobic stimulus on the photoreceptors in the eye.

As the angular width of the Dyop diameter and the gap/segments gets sufficiently smaller, the strobic stimulus is no longer sufficiently large enough for the motion of the gap/segments to be detected.

The added precision and reliance upon a visual physiological response, rather than cognition of European type letters, provides a more precise, consistent, accurate, and efficient method for measuring visual acuity. It also lets the Dyop test be used for people with limited literacy and vision for method visual acuity. It also lets the Dyop test be used for people with limited literacy and vision for children.

Exclusively available on CHART 2020
Welcome to the Dyop® Revolution

“The benefit of technology is NOT in what it lets people accomplish but in how it improves the character of people.”
- Allan Hytowitz

“In every revolution, there is one man with a vision.”
- James Kirk