Acuity and Color Acuity Screening for Infants and Children.

Poster for the Vision Science Society

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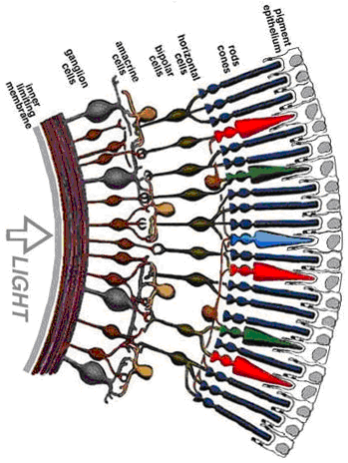
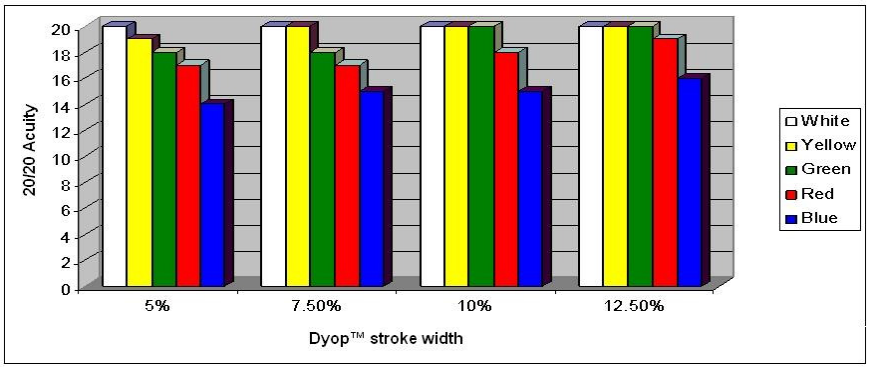
Summary:

Visual acuity has traditionally been measured as a Black-on-White process using static images despite the biological reality of visual acuity being the result of the matrix response of red (L), green (M), and blue (S) photoreceptors. The photoreceptor perception is also prioritized based upon detecting motion as well as proximity. The rotation threshold detection distance for selected color/contrast images not only correlates to acuity but also seems to correlate to reported attributes of visual dyslexia-type symptoms. Those same color/contrast detection attributes are also measureable in children.



Background:

A Dyop™ (short for Dynamic Optotype™) is a uniformly rotating calibrated image whose diameter (angular arc width), stroke width, contrast, and motion provide a revolutionary method for determining visual acuity. The Dyop™ concept is able to quantify that preference for motion and proximity with approximately three times the precision of the classic Snellen test. It is also able to verify visual perception based upon the color responses of an individual. It was discovered that the detection distance threshold for rotating colored images was different depending upon the color (White, Yellow, Green, Red, and Blue segments on a Black background) but seemed to correlate to the population distribution of colored photoreceptors.



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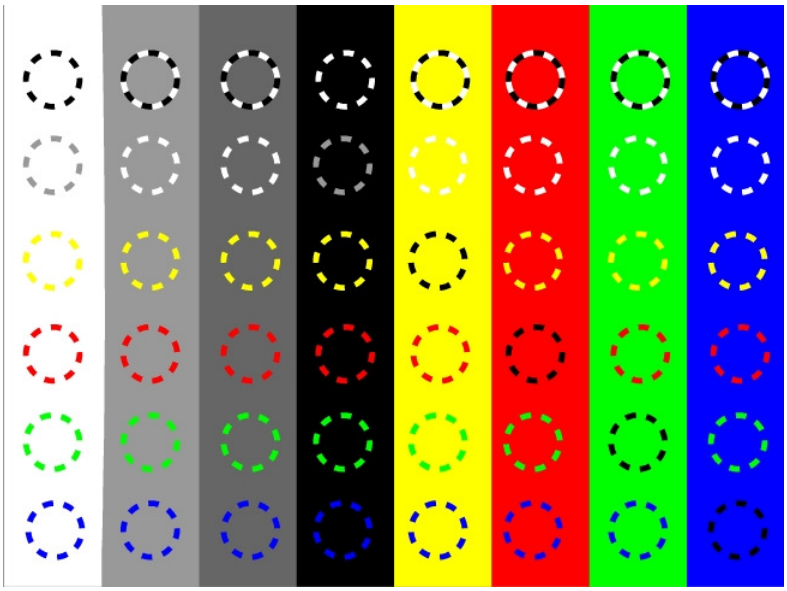
Differences in the rotation detection threshold distance for colored Dyop images prompted the creation of a color/contrast matrix of Dyop™ images.

Color/contrast Matrix of Dyop™



In the testing of the responses of individuals with known symptoms of dyslexia (as well as migraines and epilepsy) it was determined that "red-dominant" individuals were more likely to detect the rotation of an identical diameter Blue-on-Black Dyop™ image at a distance further than they were able to detect the rotation of the identical diameter Green-on-White Dyop™ image.

Green-Dominant Viewing Distance Ratios

Dyop™ Color	Black/White	Blue	Red	Green	Blue	Red	Green
Background	Gray	White	White	White	Black	Black	Black
Distance %	100%	90%	90%	70%	50%	90%	90%

Red-Dominant Viewing Distance Ratios

Dyop™ Color	Black/White	Blue	Red	Green	Blue	Red	Green
Background	Gray	White	White	White	Black	Black	Black
Distance %	100%	90%	90%	50%	70%	90%	90%

To more easily verify the difference of "red-dominant" versus "green-dominant" perception, a portable Dyop™ image color/contrast webpage based test was created using calibrated animated GIF files so that they could be used on an iPhone. (Animated GIF files were used because the current Adobe Flash Dyop™ tests cannot be displayed on an iPhone or iPad without the use of the Photon Browser.) The Dyop™ images had identical physical diameters but subjects were able to detect rotation of the different color/contrast combinations at distinct viewing distances. When as displayed on an iPhone, the calibrated (2.7 mm) diameter of Black/White-on-Gray Dyop™ images on the webpage had a 4 foot Dyop™ 20/20 Viewing Distance. Once that 20/20 rotation detection threshold distance for the Black/White-on-Gray image was determined, the subjects were asked to view each of the rotating Red-on-White, Green-on-White, Blue-on-White, Red-on-Black, Green-on-Black, and Blue-on-Black Dyops™ to determine their rotation detection viewing distance for those color/contrast images.

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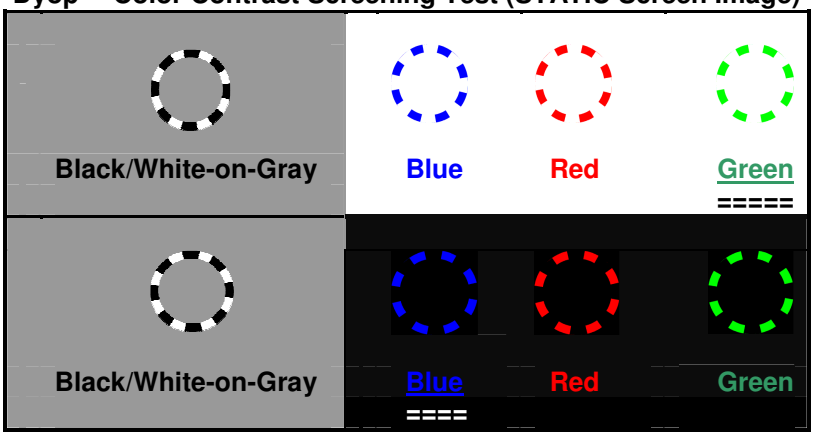
Dyop™ Color Contrast Screening Test (STATIC Screen Image)



Typically, individuals who were "green-dominant" knew that they did NOT have dyslexia and were able to detect rotation of the rotating **Green-on-White** images at a Viewing Distance of 3 feet and rotation of the **Blue-on-Black** Dyop™ images at 2 feet. They were also able to detect the rotation of the Red-on-White, Blue-on-White, Red-on-Black, and Green-on-Black Dyop™ images at a 4 foot Viewing Distance.

Typically, individuals who were "red-dominant" knew that they HAD dyslexia and were able to detect rotation of the **Blue-on-Black** Dyop™ images at a Viewing Distance of 3 feet and rotation of the **Green-on-White** Dyop™ images at 2 feet. Known dyslexic individuals were able to detect rotating Red-on-White, Blue-on-White, Red-on-Black, and Green-on-Black Dyop™ images at a 4 foot Viewing Distance.

Six individuals (5% of the test subjects) also tested "positive" for "red-dominant" vision (dyslexia-type symptoms) although they DID NOT know that they were possibly dyslexic. NO individuals who knew they had dyslexia tested as being "green dominant."

The difference in the viewing distance for detecting rotation of the Blue-on-Black Dyop™ images at a distance further than the Green-on-White Dyop™ images is indicative of dyslexia-type symptoms.

Dyop™ Color Screening Test

Color / Background	Black / White on Gray	Red / on Gray	Green / on Whit	Blue / on Black
Distance	Gray	Gray	White	Black
4 ft.	285	285	0	0
3 ft.	0	0	184	95
2 ft.	0	0	95	184

Black-on-White, Red, Green, and Blue Screening Test – 285 subjects (ages - 15 through 65)
Known NON-Dyslexics ("green-dominant" vision) – 184
Known Dyslexics ("red-dominant" vision) – 95
Un-known "red-dominant" vision types detecting Blue-on-Black rotation at 3 feet (included above) – 6

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Using Dyops to measure Acuity and Color Acuity in Infants

A factor for the increased precision of Dyop™ images for measuring acuity is that people have a predisposition to detect moving images. Dyops™ have the advantage that their rotational motion can be used to evaluate and measure an infant/child's visual response and acuity, despite an infant/child being non-verbal or not able to read. An infant/child is predisposed to focus on Dyop™ images that are rotating versus those that are static. An infant/child will also continue to focus on rotating Dyop™ images as the rotation location alternates from one side of the display to the other, and as they get incrementally smaller.

The Dyop™ Infant Acuity Test was calibrated for a web browser on a 22 inch diagonal computer monitor. When that 22 inch diagonal monitor was viewed from a distance of 3 feet, the angular arc width of the monitor was approximately 30 arc degrees. As the location of rotating Dyop™ images alternated from one side of the display to the other, that 30 arc degree angular width was usually sufficient to make head and/or eye movement noticeable to the observer as the subjects' head and/or eyes tracked the location of the rotating Dyop™ images.

When the Dyop™ image diameter (angular arc width) is less than the rotation detection threshold for the image, as either the image diameter is reduced or the viewing distance is increased, the infant/child will not be able to detect the rotation. Infant who have been predisposed to track the alternating location of the Dyop™ motion rapidly move their head from side to side trying to detect the location of what should be a rotating image. Verbal child typically validate the loss of rotation detection by exclaiming, "It's disappeared."

Methodology:

Infant Basic Acuity:

The 30 Dyop™ Infant Acuity Test subjects were initially positioned at a viewing distance of **three** feet from the monitor and tested for their response to a Black-on-White Dyop™ image on a Gray background. Of the subjects, 27 respondent initially detected and focused on the "10 foot" Dyop™ images as the location of the rotating image alternated from the **Left Panel** to the **Right Panel**. As the images got incrementally smaller from the initial "10 foot" detection threshold size to "8 foot" and "6 foot" detection threshold diameter, and the location of the rotating images alternated from the **Left Panel** to the **Right Panel**, the subjects moved their head and eyes to follow (track) the location of those rotating Dyop™ images.

When viewed from a **three** foot viewing distance, as the image diameters incrementally decreased to the "4 foot" rotation detection threshold diameter, 27 respondent subjects demonstrated their 20/20 acuity by being able to **detect** the smallest Black-on-White on Gray "4 foot" detection threshold images and track the location of the rotating image. The 3 non-respondent subjects were all under 18 months of age.

When the test was repeated with the respondent subject sitting at a viewing distance of **five feet**, and the image diameters decreased to the final "4 foot" detection threshold diameter size, non-verbal children and infants started to rapidly move their head and eyes from one side panel to the other looking to detect the Dyop™ rotation. Verbal children usually exclaimed their amazement that the images have "disappeared!"

The subject's being able to track the rotation of "4 foot" detection threshold image at a viewing distance of three feet, but NOT being able to see the same size image at a viewing distance of five feet, is indicative of 20/20 vision.

The **Selection Numbers 10, 8, 6,** and **4** at the bottom of the screen were used to reselect those sizes to verify the acuity response. (All of the subjects were observing the images with 20/20 corrective glasses or unaided vision.)

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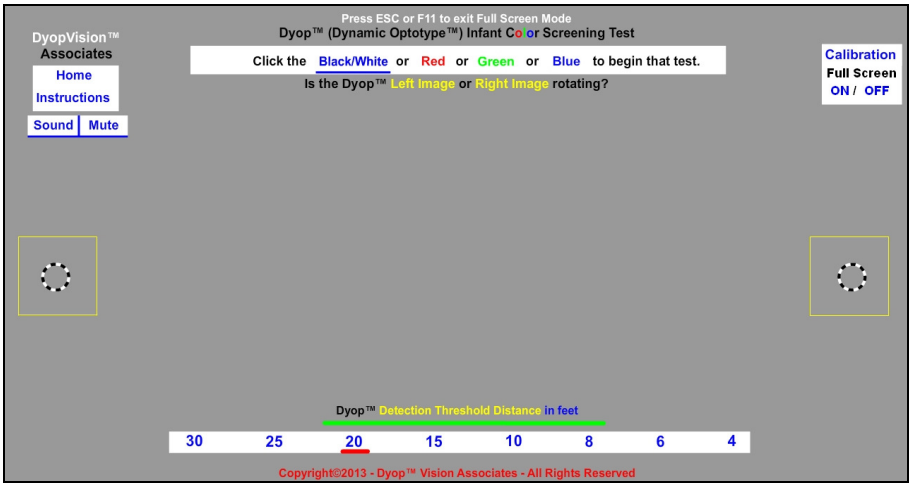
Dyop™ Infant Acuity Screening Test (STATIC Screen Image)



Dyop™ Infant Acuity Screening Test Results
(Subjects able to detect the rotating Dyop™ cluster location)

Dyop™ Color = Black-on-White on Gray = 3 foot Viewing Distance

Threshold Distance	10 ft.	8 ft.	6 ft.	4 ft.
# Respondent Subjects	27	27	27	27
# Non-Respondent	3	3	3	3

Dyop™ Color = Black-on-White on Gray = 5 foot Viewing Distance

Threshold Distance	10 ft.	8 ft.	6 ft.	4 ft.
# Respondent Subjects	27	27	27	0
# Non-Respondent	3	3	3	3

Respondent Infant/Child subjects (able to track Black/White-on-Gray Dyop™ images) – 27
Age ranges:
Subjects 6 months to 18 months of age – **5**
Subjects 18 months to 3 years of age – **6**
Subjects 3 years to 12 years of age – **16**

Non-Respondent Infant/Child subjects (NOT able to track Black/White-on-Gray Dyop™ images) – 3
Age ranges:
Subjects 6 months to 18 months of age – **3**
Subjects 18 months to 3 years of age – **0**
Subjects 3 years to 12 years of age – **0**

Infant Color Acuity:

For the Dyop™ Infant Color Acuity Test, the respondent test subjects initially viewed the color/contrast Red-on-Gray, Green-on-White, and Blue-on-Black tests from a distance of three feet from the monitor. For each color/contrast combination, the subjects initially detected the location of the rotating color/contrast "10 foot" Dyop™ images as the rotating Dyop™ images alternated from the **Left Panel** and the **Right Panel**. The color/contrast Dyop™ images had physical diameters (angular arc width) identical to those of the Black-on-White on Gray Dyops™. As the rotating images got incrementally smaller in diameter size, the subjects moved their head and eyes to follow (track) the alternating location of the rotating Dyop™ images.

An infant/child's ability to track the location of the rotating Red-on-Gray, Green-on-White, and Blue-on-Black image from their initial "10 foot" Threshold Distance size to "8 foot" to "6 foot" detection threshold images is indicative of the infant/child being able to perceive that color. The infant/child's being able to

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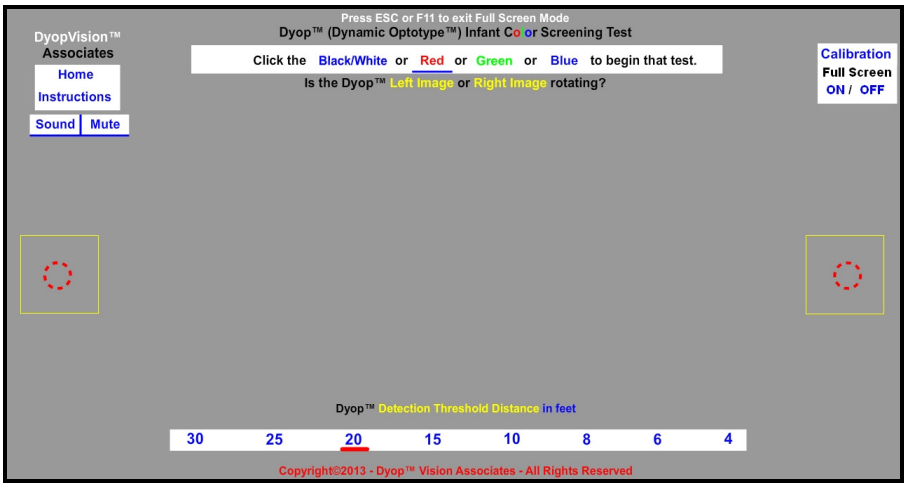
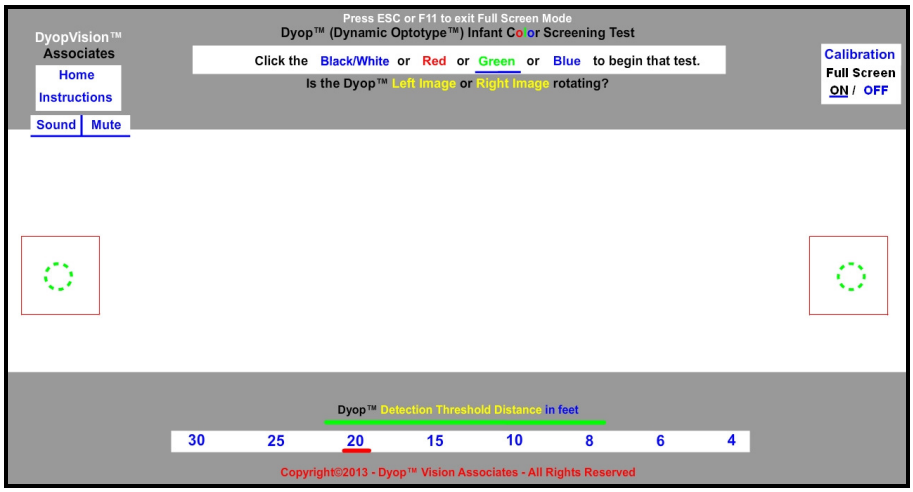
track the location of the rotating "4 foot" detection threshold Red-on-Gray Dyops™ images at viewing distance of three feet is indicative of red perception. Having to move the infant/child to a 24 inch viewing distance to track the movement of the Green-on-White Dyop™ images, but having to move the infant/child to an 18 inch viewing distance to track the movement of the Blue-on-Black Dyop™ images, is also typical of "green-dominant" vision. Having to move the infant/child to a 24 inch viewing distance to track the movement of the Blue-on-Black Dyop™ images, but having to move to an 18 inch viewing distance to track the movement of the Green-on-White Dyop™ images, is also indicative of "red-dominant" vision (potential dyslexia-type symptoms).

The subject's ability to see the Green-on-White Dyop™ images at a farther distance than the Blue-on-Black Dyop™ image is indicative of "green-dominant" vision and NOT having dyslexia-type symptoms. The subject's ability to see the Blue-on-Black Dyop™ image at a farther distance than the Green-on-White Dyop™ image is indicative of "red-dominant" vision and potential dyslexia-type symptoms. The **Selection Numbers 10, 8, 6,** and **4** at the bottom of the screen were used to reselect those sizes to verify the acuity response. All of the subjects were observing the images with corrective glasses or unaided vision.

Dyop™ Infant Color Screening Test – Red-on-Gray (STATIC Screen Image)



Dyop™ Infant Color Screening Test – Green-on-White (STATIC Screen Image)



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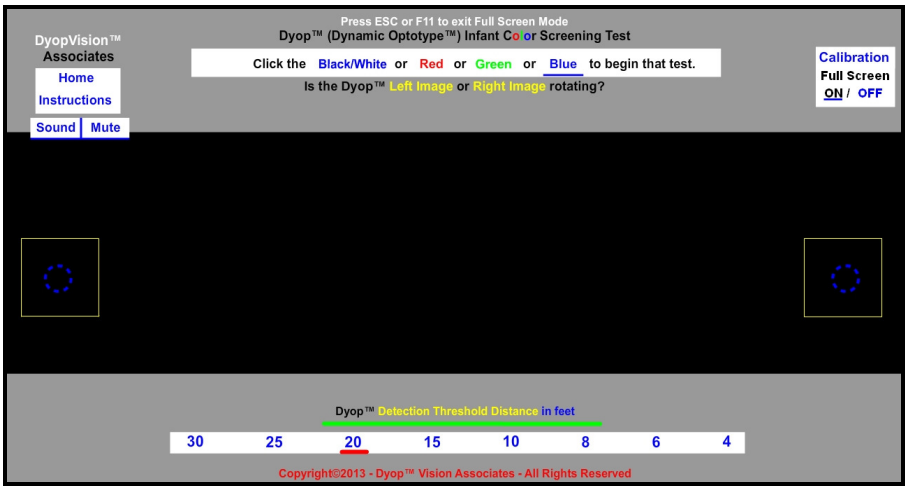
Dyop™ Infant Color Screening Test – Blue-on-Black (STATIC Screen Image)



Dyop™ Infant Color Acuity Screening Test Results (for subjects able to detect rotation)

Color / Background	Black / White on Gray	Red / on Gray	Green / on Whit	Blue / on Black
Distance	**Gray**	**Gray**	**White**	**Black**
4 ft.	27	27	0	0
3 ft.	0	0	22	5
2 ft.	0	0	5	22
None	3	3	3	3

Conclusion:

Based upon the test responses, the Dyop™ Color Acuity Screening Test can effectively be used to screen for acuity and color perception regardless of the age or verbal skills of the test subject.

Reference articles:

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Optometry and vision science: official publication of the American Academy of Optometry 2012;89(7):E1059-67.

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Paul Alan Harris, OD, FCOVD, FACBO, FAAO, Associate Professor, Southern College of Optometry
Poster, American Academy of Optometry, October 2013
http://www.dyop.org/documents/2013_AAO_Harris.pdf

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