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Case Report

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Induced Dyslexia

Allan Hytowitz

Dyop Vision Associates LLC, USA

***Corresponding author**
Allan Hytowitz, Dyop Vision Associates LLC, USA.

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Vision is a complex process combining the stimulus matrix of the photoreceptors, the transient acuity adjustment of the lenses of the eyes, and the pattern of the image as stored in the brain [1-3]. The peripheral areas of the interior of the human retina contain rod-shaped photoreceptors which are primarily sensitive to the intensity of light [4]. As light enters the eye via the cornea it is slightly bent (refracted) by the cornea and filtered by the iris to control its intensity, and then it is significantly bent by the biological lens into a spectral range of colors [5]. The anterior (foveal) area of the retina contains cone-shaped photoreceptors which in humans are primarily sensitive to the colors of either blue, green, or red [6,7]. Those colors match the sensitivities of the foveal cone-shaped photoreceptors which are primarily sensitive to the colors blue (464 nm), green (549 nm), and red (612 nm) [8]. Because of the spectral disparity (refraction) of light when the focus of the image is optimized, blue is focused in FRONT of the retina, red is focused ON the retina, and green is focused BEHIND the retina (Figure 1) [9]. The cone photoreceptor signals are sent forward to the layer of neuroganglia (Figure 2) in front of the foveal photoreceptors (Figure 3) [10,11].

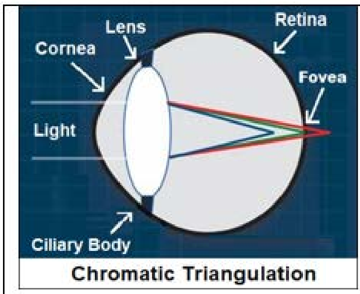


Figure 1

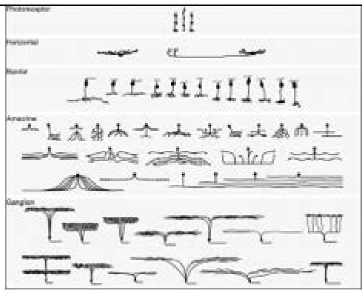


Figure 2

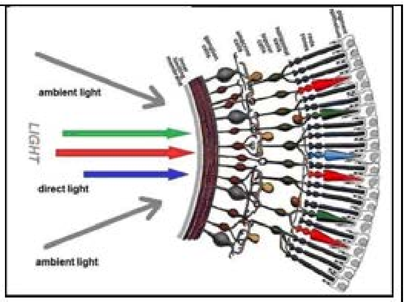


Figure 3

The neuroganglia layer of cells functions much as a biological circuit board with clusters of around 20 cone-photoreceptors being the **Minimum AREA of Resolution** for sending their neuroganglia stimuli to the cilia surrounding the lens to regulate its shape [12,13].

The adjustment of the shape of the lens to regulate the focal depth of an image is in response to the relative stimulus of the foveal photoreceptors. That process can be called Chromatic Triangulation, much like the map function for determining your location by knowing the relative direction and distance to three points on a map. Additionally, the stimulus of about 100 foveal cone-photoreceptors is sent to the neuroganglia and then sent via each optic nerve to the brain to record the visual image. However, because acuity is regulated by the color perception of the cone-shaped photoreceptors, variances in color perception have also been associated with visual infirmities such as dyslexia [13,14].

Dyslexia has typically been regarded as a neurological disorder affecting reading skills [15-18]. Individuals associated with having dyslexia are frequently called “slow readers” because of the need to read one word at a time to better enable cognition of words [18-21]. (Figure 4).

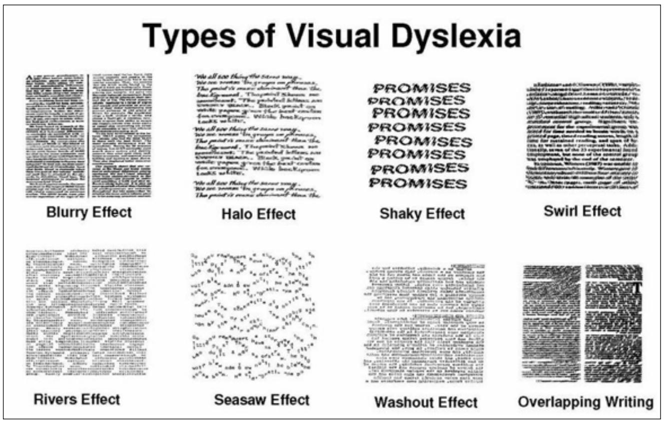


Figure 4: Those "slow readers" also have been identified as having a ratio of 75% red versus 20% green cone-shaped photoreceptors in the foveal thus contributing to **Near Vision Stress** and an unstable near images. Non-dyslexics tend to have a more balance 50% red versus 45% green cone-shaped photoreceptors and a **Stable Near Vision** facilitating both near and distance visual acuity [21,22]. (Figure 5).

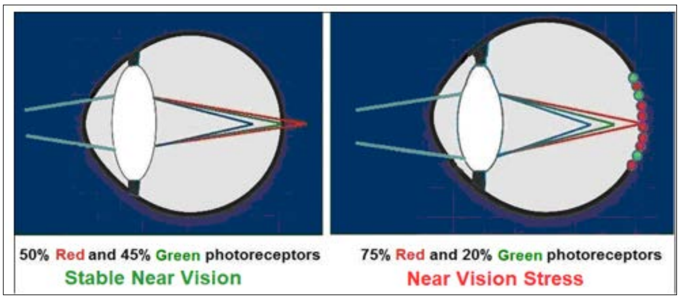
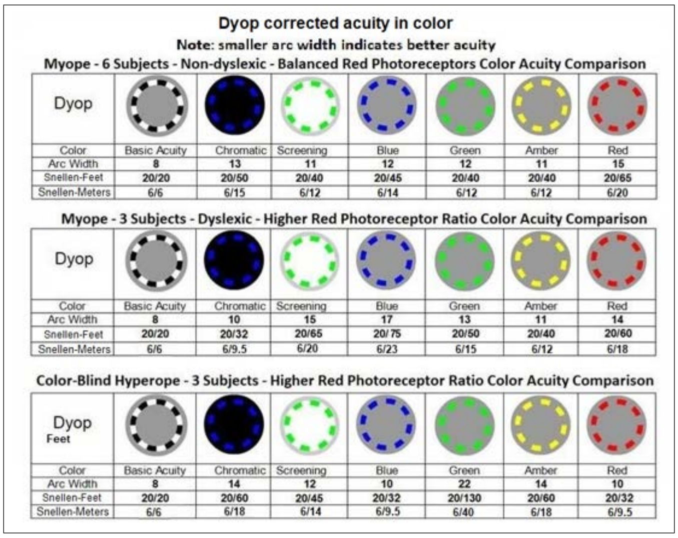


Figure 5: Recent research has independently verified a color perception correlation to dyslexia based on color permutations of the strobic stimulus of a spinning ring optotype called a Dyop® (pronounced "di-op" and short for dynamic optotype). Dyop gap/segment color/contrast permutations have distinctive, and corresponding, acuity endpoints. The qualitative acuity responses of specific Dyop color/contrast combinations have been compared to diagnosed symptoms of dyslexia where the ability to perceive a smaller diameter Blue/Black spinning Dyop versus a Spinning Green/White Dyop has a 90% correlation to symptoms of letter-based dyslexia [21-24]. **(Figure 6).** This observation correlates to the Dyop realization that acuity is regulated by the **Chromatic Triangulation** of red, green, and blue within the retina rather than being regulated by the brain. It also indicates that, rather than Dyslexia being a neurological (cerebral) difficulty, symptoms of dyslexia are associated with **Near Vision Stress** from the higher ratio of red/green photoreceptors [23,24].



Dyop corrected acuity in color

Note: smaller arc width indicates better acuity

Myope - 6 Subjects - Non-dyslexic - Balanced Red Photoreceptors Color Acuity Comparison

Dyop							
Color	Basic Acuity	Chromatic	Screening	Blue	Green	Amber	Red
Arc Width	8	13	11	12	12	11	15
Snellen-Feet	20/20	20/50	20/40	20/45	20/40	20/40	20/65
Snellen-Meters	6/6	6/15	6/12	6/14	6/12	6/12	6/20

Myope - 3 Subjects - Dyslexic - Higher Red Photoreceptor Ratio Color Acuity Comparison

Dyop							
Color	Basic Acuity	Chromatic	Screening	Blue	Green	Amber	Red
Arc Width	8	10	15	17	13	11	14
Snellen-Feet	20/20	20/32	20/65	20/75	20/50	20/40	20/60
Snellen-Meters	6/6	6/9.5	6/20	6/23	6/15	6/12	6/18

Color-Blind Hyperope - 3 Subjects - Higher Red Photoreceptor Ratio Color Acuity Comparison

Dyop Feet							
Color	Basic Acuity	Chromatic	Screening	Blue	Green	Amber	Red
Arc Width	8	14	12	10	22	14	10
Snellen-Feet	20/20	20/60	20/45	20/32	20/130	20/60	20/32
Snellen-Meters	6/6	6/18	6/14	6/9.5	6/40	6/18	6/9.5

Figure 6: That higher red/green ratio of Near Vision Stress is likely associated with evolutionary processes since it is also associated with improved distance vision which is advantageous for primitive humans as hunters and predators [28-30]. (Figure 7).

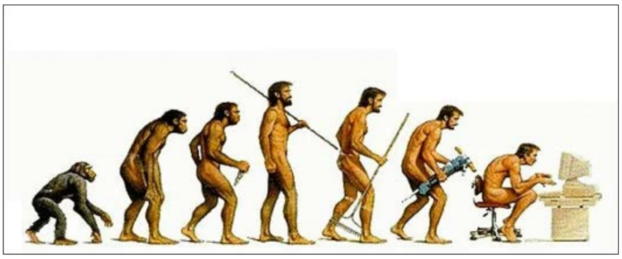


Figure 7: What **Chromatic Triangulation** of acuity also indicates is that mis-adjustment of acuity by Eye Care Professionals has an effect similar to biological dyslexia due to the reduced ability to form a **Stable Near Image**. Dyop refractions are documented to be up to three times more efficient than Snellen refractions, up to six times more precise than Snellen refractions, and up to eight times more consistent than Snellen refractions. However, Snellen refractions in comparison to Dyop refractions have consistently been shown to induce excess minus power of 0.25 diopters to 0.50 diopters [24-32]. That excess minus power leads to angular elongation of the eyeball and a potential increase in myopia. Ironically, it may indicate that the 1862 Snellen test itself may be a causative factor in the recent Global Epidemic of Myopia [31].

That excess refractive minus power may also be a factor in an increase in conditions associated with traditional dyslexia.

Induced Dyslexia where the reduced ability to comprehend letter-based text may be caused by mis-prescribed eyeglasses and/or contacts [31].

Cataract-Induced-Dyslexia where the reduced ability to comprehend letter-based text may be caused by the reduced acuity associated with cataracts OR by the mis-prescribed IOL lenses used to compensate for the removal of the cataract affected lenses [34].

The topic of **Induced Dyslexia** was first discussed when the author discovered in 2006 that his 2002 progressive lenses had been over-minused by **ONE DIOPTER** in each eye by a newly visited Optometrist [28]. **(Figure 8).**

Figure 8: The "problem" that most people have with acuity is that unless it is identified and quantified by an "Eye Care Professional" it becomes almost impossible for an individual to identify the visual aberration from "perfect" or optimum vision. It took four years of visual trauma and the total loss of income to realize and recognize that the "problem" was not mental or physiological as to "early Alzheimer's" or a "brain tumor" or "hysterical blindness" but that the loss of the ability to read documents or comprehend the contents of my computer monitor was from that excess minus power in my lenses. During this period, I could drive a car, watch TV, and go camping with my Boy Scouts. It was only a fluke that when speaking to someone about my vision problems, I realized that I could not clearly see the person sitting six feet away from me. When I went to a "Mall Optometry Shop" the next day, the Optician incredulously asked, "Where did you get these glasses?" Based on the consistent and preliminary comparison of using a Dyop for refractions versus using the "classic standard" Snellen test, it is likely that a lot of people fail to realize that by having a Snellen refraction they are inherently being over-minused by 0.25 diopters to 0.50 diopters, or more. The "problem" of that over-minused refraction is that it contributes to axial elongation and an increased potential for increased myopia. While current research indicates that individuals with myopia tend to have increases in their myopia with age, it has yet to be sufficiently validated that the inherent Snellen over-minus might be a contributing factor.

Since the physiological effect of color perception has a correlation to dyslexia, it might be possible that one of the unnoticed cataract symptoms of is not just blurry vision and the aberrant color perception changes a person sees (such as a yellow or greenish tint to everything). However, a subject with cataracts frequently does not notice the loss of visual clarity or cognition unless the diagnosing Eye Care Professional explains the details. Interestingly enough, a coping mechanism of those with dyslexia is to learn to read sentences and words more slowly so that more time is spent on cognition. Those who have undiagnosed dyslexia also seem to develop symptoms of excess confidence as a coping mechanism for their skills and literacy level (aka, the Dunning-Krueger Effect) [35].

While this Case Report may be personal in nature, there is sufficient validation of the cognitive effects of aberrant acuity associated with excess minus power. Much of the visual stress associated with "modern" electronic devices is possibly because of both the inherent Near Vision Stress from excessively close vision but also from refraction standards created when the telegraph was the primary means of distance communication. It might behoove the Eye Care Profession and the general population to re-examine the visual needs of the 21st century versus the needs of the 19th century when less than 20% of the most advanced societies had a literate population.

To further illustrate the Dyop concept and attributes, a visual explanation and free online acuity and dyslexia screening tests are available at www.dyop.org. A link on that page also has the offer of a complimentary copy of the Dyop Professional test for research use which provides even more precise acuity and refraction measurements.

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Footnotes

The Dyop test evaluates motion perception using a spinning ring to detect visual acuity thresholds, unlike static letter charts.

The term “induced dyslexia” refers to dyslexic-like symptoms not caused by genetics but by exposure to excessive light stimulation and/or an improper visual refraction during reading.

Early digital monitors used green-phosphor on black because it caused less retinal stress and was easier to read for extended periods.