

A Review on Color Vision Deficiency

Arpan Chakrabarti

Assistant Teacher, Department of Life Science, Paschim Gabberia High School, South 24 Paraganas, West Bengal, India

Abstract: Color vision deficiency (CVD) is characterized by the inability or decreased ability in perception of some specific colors. CVD is further divisible into several types, of which red-green color vision defects are the most common whereas blue-yellow color vision defect is rarer. These kinds of CVDs interrupt color perception but do not impinge on the sharpness of vision. CVD may be X-linked recessive or an autosomal dominant or very rarely an autosomal recessive trait associated with X chromosome or chromosome 7 or 2 or 8 or 10. CVD in a subject is detected and its severity is analyzed by means of several tests, viz, Ishihara Pseudochromatic Test, Lantern Test and Anomaloscope test. The prevalence of CVD varies worldwide and some parts of the world show considerable prevalence. It is very important to identify CVD affected individuals, mild or severe, at an early age by proper counseling in order to guide them in selection of the suitable career path. Few countries have initiated awareness and counseling program for CVD affected individuals, however it is imperative for all countries to take necessary steps in this regard.

Keywords: Color vision deficiency [CVD], chromosome, Test, Prevalence, Counseling.

1. INTRODUCTION

One of the chief characteristic features of humans is that they have three different channels of vision for conveying color information related with three different cone cells. However, when there is an error in the development of one or more types of retinal cone cells that receive color in light and transmit that information to the optic nerve, color vision deficiency [CVD] occurs [1]. There are three kinds of major color vision genes are present in humans- short wavelength sensitive [SWS] genes, medium wave length sensitive [MWS] and long wave length sensitive [LWS] genes [2,3]. Congenital CVD may be a X chromosome-linked recessive, an autosomal dominant and very rarely an autosomal recessive trait [3]. Red green CVD shows the highest prevalence among all types of CVDs [4]. Red-Green CVD is divisible into severe or dichromatic forms (protanopia and deuteranopia) and milder or anomalous trichromatic forms (protanomaly and deuteranomaly) [5,2]. In dichromatic color vision, there is complete absence of one type of photoreceptor cone cells and in anomalous trichromacy, all of the three types of cone cells are used to perceive light colors but one type of cones show weakened color saturation [2]. Protanopia is caused by the complete absence of red retinal photoreceptors while absence of green retinal photoreceptors causes deuteranopia. Protanomaly or red weakness is characterized by the presence of normal blue and green sensitive cones with anomalous green-like cone where as deuteranomaly or green weakness is characterized by the presence of normal blue and red sensitive cones with anomalous red-like cones [5]. These subjects are regarded as anomalous trichromates and though they recognize color in red-green region, the color saturation is weakened. There is another type of CVD, tritanopia which is caused by missense mutation of the gene on chromosome 7 [5]. This gene encodes the S or blue retinal cone pigment. In this defect, erroneous color discrimination happens in the short-wave region (blue-yellow) of the spectrum. People affected by tritan color blindness confuse blue with green and yellow with violet color. Unlike the red-green CVD, tritan defects are found in both males and females equally as it is an autosomal dominant trait [5]. The tritan defects are very rare and show a prevalence of 1 in 15 000 to 1 in 50 000 [0.002 - 0.007%] of the population [1]. Another CVD, the achromatopsia or total color blindness is characterized by reduced visual acuity, photophobia and reduced or complete loss of color discrimination. It is also an autosomal recessive inheritance and the associated genes are present on chromosome 1,8,10, and 12 [5].

2. TYPES OF CVD

CVD can be categorized into several types according to its character and severity. There are several type of CVD prevailing world wide. Figure 1 represents the types of CVDs prevailing worldwide [5,6] –

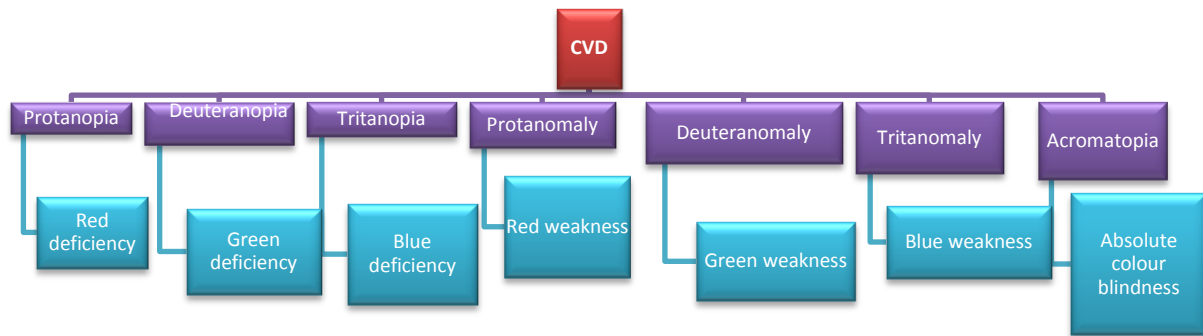


Fig 1: Types of CVD and their particular color perception abnormality

Genes involved:

Mutation of the following genes are involved in causing different types of CVD [5]-

Table 1: Different genes and chromosomes associated with CVDs

CVD	Protanopia	Deuteranopia	Tritanopia	Acromatopia
Mutated Genes involved	OPN1LW [opsin 1 long wave]	OPN1MW[opsin 1 middle wave]	OPN1SW [opsin 1 short wave]	GNAT2, CNGA3, CNGB3, , and PDE6C
Chromosome containing the Gene	X chromosome	X chromosome	Chromosome 7	chromosome 1,2,8 and 10 respectively

3. DETECTION OF COLOR VISION DEFICIENCY

a) Detection of protanopia and deuteranopia

Table 2: Procedures of protanopia and deuteranopia detection

Test	Description
Ishihara Test	The subjected to 38 plate edition of Ishihara Test Plates [ITP] following the recommendation of Ishihara [7] and International Recommendations for Color Vision Requirements [8]. Suitable fluorescent lamps with excellent color rendering properties are needed for this test.
Lantern Test	The Farnsworth Lantern [FALANT] test is a color-naming test is used to detect dichromates. Color pairs (including red, green, and white) are shown and the pass/fail level is based on the number of color-naming errors. Subjects with dichromatic vision fail in this test. [5]
Anomaloscope	A more sophisticated instrument is the anomaloscope, which requires color matching. The person views a pure yellow light on one half of a screen while the other half projects a mixture of red and green lights. The brightness of the yellow light and the proportion of the green and red lights are adjusted by the person who is tested until both hemi-fields appear identical in color and brightness. The range and midpoint of accepted matches of the proportion of green and red light are recorded. [5]

b) Detection of protanomaly and deuteranomaly**Table 3: Procedures of protanomaly and deuteranomaly detection**

Test	Description
Ishihara Test	To detect protanomaly and deuteranomaly [both strong and mild] among the students, the Ishihara Test [7] available, depending on the difficulty in detecting the numbers and pathways in the background. This study was done with plate numbered 22 to 27 following recommendations of Ishihara.[7]
Lantern Test	75% of anomalous trichromats fail this test [5]
Anomaloscope	Most accurate in classifying protanomaly and deuteranomaly.

c) Detection of Tritanopia and Tritanomalia**Table 4: Procedures of tritanopia and tritanomaly detection**

Test	Description
The American Optical HRR pseudoisochromatic test	The American Optical HRR pseudoisochromatic plates detect tritan defects while the Ishihara plates do not detect the tritans accurately [5]

4. PREVALENCE

Several studies have reported that prevalence of color vision deficiency varies according to the ethnic background of an affected individual [6]. A study from Pune, India reported 2.02% of overall prevalence of CVD [9] though another study from Manipur, India shows as high as 8.16 % frequency of CVD among individuals of Meitei population though the same study reported 2.86% prevalence among Naga population [1]. Additionally, a study from Pakistan showed only 3.1% of male students of school showed CVD [10]. Ahsana et.al reported that Asian males have a prevalence of color vision defects of 4.9% compared to 0.6% in females [1]. However, the Caucasian population which shows 8% prevalence of CVD in males [11] and young Jordanians shows the prevalence of 8.72 % in males [12]. Additionally, among individuals of northern European descent, 0.5% of females have red-green color vision defects [5] though a study from another country, Nepal shows 0 % prevalence among female school students [13]. The reason is CVD is an X-linked recessive disorder. Males of northern European descent show about 8% of prevalence while this defect is significantly less frequent among males of African [3%-4%] or Asian [3%] ancestry [5].

5. COLOR VISION DEFECT AND COUNSELING

CVD does not cause complete blindness and there is no available therapeutics that can treat CVD. It is regrettable that many of the CVD patients are unaware of their disorder. In a survey, Harris and Cole reported that among 293 cricketers 26 suffered from color blindness of whom only 58 per cent were aware of their CVD status [14]. However, it is not always easy for the physicians to explain eye conditions to patients and advise on its hazardous effects. As CVD does not cause any severe disability and the condition persists from birth of the affected individuals whose experience of color is totally different from that of normal individuals, it is very difficult to make them know about their deficiency. Some occupations have a statutory color vision requirement but these may vary between countries and between states within a nation. These include pilots, deck officers and seamen, loco pilots, air traffic controllers, some occupations in the defense forces, geological service, lab technology and histopathological laboratory jobs. In India, a considerable number of desirable candidates are rejected each year in pre employment medical testing in the services mentioned above due to the presence of CVD. So it is very crucial to identify and guide a CVD affected person at an early stage. The basic level of awareness among students and their family members must be increased as an affected individual's career can be rescued only when he/she is informed about his/hers deficiency at an early stage of life. Organizations like "Color Vision Awareness" often arrange awareness programs in British schools and according to their recent survey there are approximately 400,000 color blind students present in British schools of which 95,000 have severe condition [15]. Tinted contact lenses with individually preferred filters may be an alternative to improve color discrimination [5]. In Japan, the Education Ministry issued guidance on how to make classroom accessible to students with CVD and even ensured suitable text books for color blind students in the year 2003 [16].

6. CONCLUSION

Color vision deficiency is a common ocular defect of human being associated with chromosome. CVD affected subjects face severe or mild troubles with red, green, blue or yellow color perception. Optometrists and ophthalmologists follow several tests to diagnose CVD affected subjects. CVD is not restricted to a few parts of the globe and but is ubiquitous. Thought there are no therapeutics available for treatment of CVD, counseling and awareness program can help the affected individuals to minimize its adverse effects to some extent. More research work is necessary in this regard in understanding the ocular difference in individual with CVD, so that, optometrist can be better equipped to diagnose and guide the affected individuals.

REFERENCES

- [1] Shah A, Hussain R, Fareed M, Afzal M [2013] . Prevalence of Red-Green Color Vision Defects among Muslim Males and Females of Manipur, India. . Iranian J Publ Health; 42 : 16-24
- [2] Nathans J, Piantanida TP, Eddy RL, Shows TB, Hogness DS [1986]. Molecular genetics of inherited variation in human color vision. Science ; 232: 203-210.
- [3] Poole CJM, Hill DJ, Christie JL, Birch J [1997]. Deficient color vision and interpretation of histopathology slides: cross sectional study. BMJ, 315: 1279-1281. Doi: 10.1136/bmj.315.7118.1279
- [4] Oriowo OM, Alotaibi AZ [2008]. Color vision screening among Saudi Arabian children. S Afr Optom; 67[2]: 56-61
- [5] Deeb SS, Motulsky AG [2011]. Red Green Color vision defect. GeneReviess ® [Internet]; Available from <http://www.ncbi.nlm.nih.gov/books/NBK1301/>
- [6] Karim JK and Mohammed AS. Prevalence of congenital Red Green color vision defects among various ethnic groups of students in Erbil city. Jordan Journal of Biological Sciences. Volume 6[3]: 235-238
- [7] Ishihara S [1917]. The series of plates designed as a test for color deficiency. 38 plate edition. Kenehara Trading Inc. Tokyo, Japan <http://www.scribd.com/doc/246420820/Ishihara-38-Color-Blindness-Instruction> [cited 03 March ,2013]
- [8] Cole B, Mddocks J, Adams A, Bandyopadhyay S, Birch J, Acosta J, Dain S, Hedin A, Kitahara W, Schwab R, Tansley B, Viénot F, Vos J, Walraven P [2001] International Recommendations for Color Vision Requirements for Transport. CIE-UK 2001; 143
- [9] Agarwal S, Bansod N [2014] Prevalence of color blindness among school children. International Journal of Science and Research [Internet]; vol:3, issue:4 page:2. Available from http://www.ijsr.net/v3i4_01.php#sthash.LZEEdifjg.dpbs [cited 27 Nov,2014]
- [10] Siddiqui QA, Shaikh SA, Qureshi TZ, Subhan MM [2010]. A comparison of red-green color vision deficiency between medical and non-medical students in Pakistan 2010. Saudi Med J.[8]:895-9
- [11] Ganong W. F. Review of Medical Physiology. Twenty fourth edition. Tata Macgrawhill Education Pvt Ltd, New Delhi ; Pp 193
- [12] Al-Aqtum MT, Al-Qawasmeh MH [2001] Prevalence of color blindness in young Jordanians. Ophthalmologica; 215[1]:39-42
- [13] Shrestha RK, Joshi MR, Shakya S, Ghising R [2010] Color vision defect in school going children. JNMA J Nepal Med Assoc.;50[180]:264-6
- [14] Harris RW, Cole BL. [2007] Abnormal color vision is a handicap to playing cricket but not an insurmountable one. Clinical and experimental optometry. 90 : 451-456
- [15] Color Blind Awareness.Teachers-Advise-Booklet-Secondary-School-3Availablefrom:<http://www.colorblindawareness.org/wp-content/uploads/2011/10/TEACHERS-ADVICE-BOOKLET-SECONDARY-SCHOOL-3.pdf> [cited August 2014]
- [16] Gordenkar A. Colorblind school kids can see clearly now. The Japan Times, Life, 2003 Dec 18, [cited 2014 August] Available from <http://www.japantimes.co.jp/life/2003/12/18/lifestyle/colorblind-schoolkids-can-see-clearly-now/#.VKGCmF4Ac>.