The human eye is a truly remarkable and intricately designed system. A healthy eye has millions of retinal photoreceptors in the form of rods and cones, allowing us to translate light into color. As a result, most of us are able to see at least a million different colors, with some experts maintaining that the true number is as high as 10 million.[1] This astounding perceptive ability is surpassed by few species in the natural world and suggests that color vision has conferred important evolutionary benefits for humans, perhaps explaining why we have developed such strong emotional associations with and preferences for certain hues. However, congenital or acquired damage to any component within the delicate optical apparatus can impair your ability to accurately perceive color and there are a number of inherited disorders, diseases, and medications known to interfere with color vision.

Inherited Color Vision Disorders

Most color vision impairment is the result of inherited color vision disorders that arise due to abnormal photoreceptor cell function, including:

Red-Green Color Blindness: Red-green color blindness is a sex-linked trait and by far the most common color vision disorder, affecting up to 8% of men and .5% of women. This type of color blindness results from missing or damaged L-cones (protanopia or protanomaly) or missing or damaged M-cones (deuteranopia or deuteranomaly), creating difficulties distinguishing between reds and greens as well as blues and greens, grays, and purples.

Blue-Yellow Color Blindness: Blue-yellow color blindness is far rarer than red-green color blindness, representing only 5% of people with color vision disorders, and is not sex-linked. This condition can either take the form of tritanopia, in which S-cones are completely missing, or tritanomaly, in which S-cones are present but damaged. Blue-yellow color blindness can be a misleading name, as the disorder does not create difficulties distinguishing between blues and yellows, but, rather, causes those with the disorder to "confuse blue with green and yellow with violet."[2]

Achromatopsia: Achromatopsia is a hereditary disorder that results from abnormal cone function, significantly reducing or eliminating your ability to see color. Unlike what is typically called color blindness, achromatopsia is rare, affecting 1 in 33,000 people in the United States, and involves a complete or near-complete lack of color vision; in the most severe cases, you see only shades of white, black, and grey. In addition to impaired color perception, achromatopsia also causes a number of additional vision problems, including involuntary eye movements, low visual acuity, and increased light sensitivity.

Cone-rod dystrophy: Cone-rod dystrophy is an inherited disease that damages light-sensitive cells in the retina, impairing vision sharpness, peripheral vision, and color perception in an estimated 1 in 40,000 people.[3] In some cases color vision impairment is present at birth while in other cases photoreceptors deteriorate over time to progressively impede color perception.

Diseases

There are a number of congenital and acquired diseases that compromise the ability to see and/or recognize colors due to ocular damage, including:

Cataract: A cataract is "a progressive cloudiness, hardening, and yellowing of the normally transparent lens of the eye," reducing your ability to perceive both contrast and color as your vision takes on a yellow or brownish tint.[4] Cataracts are perhaps the most common cause of color perception impairment, affecting approximately 50% of Americans between 65 and 74. In some cases, cataracts can begin developing significantly earlier, particularly those types that result from health conditions such as diabetes.

Diabetes: Diabetes can have a profound impact on eye function and is the primary cause of blindness in American adults. The disease can also disrupt your ability to perceive color, particularly on the blue-yellow axis, and color vision may fluctuate with sugar levels.

Glaucoma: Glaucoma is an umbrella term encompassing a number of eye conditions resulting in optic nerve damage. Many people with glaucoma experience difficulty distinguishing between colors and color perception impairment is often one of the first symptoms of the illness.

Macular degeneration: Damage to the macula—the part of the retina that facilitates sharp, central vision—can result in a variety of visual impairments, including reduced photostress responsiveness, blurred vision, and reduced color recognition. Specifically, your ability to distinguish between similar shades is compromised.

Alcoholism: Chronic alcohol abuse is known to produce ocular changes that impair color vision. Researchers believe that these changes may primarily affect the blue-yellow axis, although some alcohol-related dyschromatopsia includes red-green color vision loss as well. Most research on the effects of alcohol on color vision has concentrated on those with sustained, long-term histories of alcohol abuse, but a recent study on young alcohol consumers without histories of alcoholism suggests that even casual drinking amongst adolescents and young adults may result in "subclinical colour vision losses."[5]

Medications

Color vision can be temporarily or permanently affected by some types of drugs, including a number of heart, blood pressure, and psychotropic medications:

Lorazepam: Lorazepam, also known as Ativan, is a benzodiazepine used to treat symptoms of anxiety, and can cause color vision disturbances such as diminished ability to perceive color.

Viagra: Viagra, an erectile dysfunction medication, can result in "a blue tinting of the vision, called cyanopsia" in the hours following drug intake. This effect has been observed in up to half of users and is temporary, allowing your vision to return to normal after use.

Digoxin: Digoxin is a drug used to treat congestive heart failure as well as atrial fibrillation and can result in yellow colored vision as well as a range of other optical disturbances that may decrease accurate color perception.

Gilenya: Gilenya is a relatively new medication used to treat multiple sclerosis and may produce changes in color vision, including tinting.

Hydroxychloroquine: Hydroxychloroquine is an antimalarial drug also used to treat a variety of health conditions, including rheumatoid arthritis, systemic lupus erythematosus, and discoid. Long-term use may lead to retinal damage that creates color vision impairment, including difficulty distinguishing between colors.

Towards Objective Color Assessment

While the human eye is a finely designed instrument of extraordinary complexity, it is also a highly vulnerable to compromised color perception due to biological, social, and environmental influences. As such, visual assessment of critical chromatic information is inherently unreliable, potentially resulting in the release of defective and inconsistently colored products.

Today's sophisticated spectrophotometric instruments provide precise, accurate, and repeatable color measurements to ensure correct coloration of all types of materials using a range of optical geometriesthat can both replicate perfect human vision and go beyond the limits of the human eye. By using spectrophotometers to assess color through research and development stages or integrating spectrophotometric instrumentation within your production line, you can be sure that color is measured the same way every time, regardless of operator or location. The objective data provided by these advanced color measurement technologies allows you to easily share relevant color information throughout your supply chain, creating a universal language of color that cuts across culture, biology, and environment and does not depend on individual perceptive ability.

Full article with photos available here:

https://www.hunterlab.com/blog/color-measurement-2/understanding-color-vision-impairment-and-need-for-objective-color-measurement/