Colour perception in skin disease diagnosis

Color Perception – Dermatologist's perspective

Abstract:

Light and color are two important tools for the dermatologist in diagnosing skin diseases. Many articles have focused on the importance of light and illumination but there are only scanty literature about the importance of color perception. The definitions of color, color spaces and their types, assessment of color and its applications, recent advances in human color vision is reviewed.

Key words: Color, colorspace, RGB, CIE L*a*b*, Spectrophotometry, Colorimetry

Color perception is due to the evoked neural responses in the eye and visual cortex because of light stimulus. Colors differ from each other in wavelength, intensity, and saturation. The importance of color in plants ranges from attracting insects for pollination to production of bright colored fruits for seed dispersal. Color pigments are present in many animal species and has evolutionary importance for searching food, escaping from predators etc. Human skin color is linked with evolution and is changing according to the environment where humans live. Color science has various implications in telemedicine, dentistry, biometrics, anthropology, cosmetics, textiles , artificial intelligence, etc . Color of the human skin, mucosa, nails plays an important part in the social communication , diagnosis and treatment of dermatological disorders. Dermatologists need to know about the biophysics of skin, eye , color spaces , illumination sources to understand about perception of color .

All visible colors to human eye can be produced by some combination of the three primary colors, either by additive or subtractive processes. Human color perception is most sensitive to light in the yellow-green region of the spectrum. We have three types of cone receptors for the long(L), medium(M), short (S) wavelengths. The balance of neural activity in these three receptors accounts for the millions of color shades. This is utilized by the Bayer array in modern digital cameras. The number of L, M, S color sensitive cones in the human retina differs among people by up to forty times. Human perception of color is controlled much more by the brain than by the eyes. Color vision has distributed processing in the cortex, with a number of brain zones being involved in processing wavelength data and creating color sense . Cone receptors in the human eye lose their color sensitivity with age, but subjective experience of color remains same over the years. The perception of color is flexible and relies on biological processes in the brain and eye.

Phenotyping based on skin color has been attempted by many researchers the well known one is Fitzpatrick’s I to VI skin types. Though there are some drawbacks in this classification this is useful in a variety of ways – treating diseases with phototherapy, in predicting the post inflammatory hyperpigmentation, for making skin colored prostheses , skin grafting etc. Human skin color can also be classified by visual color matching using the Munsell charts. But visual clinical methods of skin color evaluation for diagnostic purposes are so far mostly subjective and inaccurate.

Many studies quantitate the skin color based on the spectrophotometry or tricolorimetry measurements which gives the absolute values of the color.

The spectral reflectance provides a lot of biological and medical information about skin and mucosa. In case of non availability of these equipments digital cameras and software has been employed to compare and quantitate human color taken under standard conditions.

Analysis of color data has to be done by a conceptual tool called color space. Color space aid the process of describing color between people , between software or machines. Color gamut is the area enclosed by a color space in two or three dimensions. Color space is useful to understand the color capabilities of a particular device or digital image and also useful to identify colors in a more intuitive way. There are many color spaces – sRGB, Adobe RGB, L*a*b*, L*u*v*, CMYK etc. Different color spaces are better for different applications.

RGB is used in many display devices – computer monitor, digital camera or a television, which uses these as its base colors. CMYK is more commonly used in printers. However, no two display devices are equal. A color shade defined by certain value of RGB on one device may look completely different on another device. A device dependent color space is a color space where the color produced depends both the parameters used and on the equipment used for display. Many devices have their own device-dependent RGB color spaces. RGB space can be visualised like a cube with the three axes corresponding to red, green and blue.

L*a*b* color space proposed by CIELAB is popular because it is device independent and the L parameter has a good correlation with perceived lightness.

It is non linear and intended to mimic the logarithmic responses of the human eye. Any color can be described by a combination of three coordinates, L*, a*, and b* , where L* is the total quantity of light reflected , a* represents color ranging from red to green , and b* represents color ranging from blue to yellow . L* measures the brightness component of color, and it varies on an achromatic gray scale between a value of 0 (black) to100 (white). The a* and b* coordinates can be converted into hue angle and chroma of color . Hue refers the degree to which a stimulus can be described as similar to or different from stimuli where 0° represents red and 90° represents yellow. Chroma describes the intensity of color, with higher chroma indicating greater intensity.

Melanin density and distribution can be assessed by the L* values wheras erythema can be known by the a* values. The color of gluteal region can be taken as the constitutive color whereas the cheek will give details of the facultative color. Skin that is usually exposed to the sun has a more intense red component, presumably because of increased vascularization. Exposed skin also showed lower reflectance (L*) than covered skin, probably because of melanin . Higher L* levels were associated with lighter skin, tendency for sunburn and less tanning .

Han K et al (1) observed that the L*a*b* color space to be the most popular system used to measure skin color. The average L*a*b* values for the body parts were 61. 74, 9. 56 and 17. 07, respectively. The site of lightest skin was found to be the medial arm , whereas the darkest was on the forehead . Redness was highest on the cheek and lowest on the medial arm . Skin color was lighter and more yellow in females than in males, whereas redness was higher in males. The factors that significantly influenced L* were sex, work place and sunbathing, factors that influenced a* were sex, work place and smoking; and the factors that influenced b* were sunbathing and age .

Ian LWeatherall et al (2) did color measurement in ventral forearm of skin of 99 subjects and expressed the results in terms of color space L * , a*, and b* values. L* values ranged from 59. 7 to 73. 4. The hue angle ranged from 54. 0 to 77. 8degrees. The chroma values ranged from 13. 2 to 21. 6. These color-space parameters are proposed for the unambiguous communication of skin color information that relates directly to visual observations of clinical importance or scientific interest.

Yun et al (3) introduced a new technique to measure L*a*b* color coordinates and the melanin and erythema indexes at the same time by analyzing the skin color of normal Asians . While the correlation of the melanin index with the L* value was negative, it was positively correlated with the a* and b* values. While the erythema index showed a weak correlation with the b* value, its correlation was negative with the L* value and positive with the a* value.

Change in colorimetric values of bruises over time was significant for all three color parameters (L*a*b*), the most notable changes being the decrease in red (a*) and increase in yellow (b*) starting at 24 h.(4)

Colorimetric skin color values can also be used to studypigmentationcapacity, to predict the risk of actiniccancer, in the study of reactions induced by physical and allergic stimuli , for choosing appropriate sunscreens (5)

Comparison using cheaper and novel ideas in this regard is yet to come. Recent advances in Information technology has allowed us to understand color vision and to extract the true color of the skin.

REFERENCES

1) Han K, Choi T, Son D et al Skin color of Koreans: statistical evaluation of affecting factors. Skin Research and Technology 2006; 12(3): 170-7

2) Ian LWeatherall1and Bernard DCoombs Skin Color Measurements in Terms of CIELAB Color Space Values . Journal of Investigative Dermatology 1992; 99: 468–473.

3) Yun IS, LEE WJ et al Skin color analysis using a spectrophotometer in Asians. Skin Res Technol. 2010 ; 16(3): 311-5.

4) Scafide, K. R., et al. Evaluating change in bruise colorimetry and the effect of subject characteristics over time. Forensic Sci Med Pathol 2013; 9(3): 367-376.

5) Andreassi , Flori L Practical applications of cutaneous colorimetry. Clinics in Dermatology 1995; 13(4): 369-73