

# Color: Its Science and Esthetics-A Review

Dr Waseem-Ul-Ayoub<sup>1</sup>, Dr Raisa Rashid<sup>2</sup>

<sup>1</sup>Resident, Prosthodontics, Government Dental College, Jammu & Kashmir, India

<sup>2</sup>Resident, Prosthodontics, Government Dental College, Jammu & Kashmir, India

**Abstract:** *To restore a tooth to its functional health, four basic determinants of dental esthetics; position, contour, texture and colour in the said sequence are required. Clark<sup>1</sup> said, "Color, like form, has three dimensions, Hue, Value, and Chroma. An understanding of the science of color and color perception is crucial to success in the ever-expanding field of esthetic restorative dentistry. It is possible to arrange color in a manner that makes this three-dimensional enigma understandable. The Munsell Color Order System is recommended as the system of choice for dentists who wish to gain a working knowledge of color.*

**Keywords:** esthetics, pigment colors, psychologic, psychophysical

## 1. Introduction

To restore a tooth to its functional health and provide it with a natural appearance is a combination of skill, talent and knowledge acquired by the dentist. This involves considering the four basic determinants of dental esthetics ; position, contour, texture and colour in the said sequence. The purpose of this article is to explore the three-dimensional nature of color.

Esthetics is the science of sensitive perception; in a narrower sense: the science of beauty. According to Microsoft "Encarta 97" encyclopedia (1997) esthetics is a branch of philosophy concerned with the essence and perception of beauty and ugliness. A German philosopher Baumgarten introduced the term esthetics in 1753, but the study of the nature of beauty had been pursued for centuries.

Albert Einstein is reported to have said, "If you cannot explain it simply, then you do not understand it well enough." This appears to be the problem regarding color matching. In a time of growing interest in cosmetic dentistry, there is a need for adequate training and communication for better and more life like results.

Forty years ago, Clark<sup>1</sup> said, "Color, like form, has three dimensions, but they are not in general use. Many of us have not been taught their names, nor the scales of their measurement. In other words, we as dentists are not educationally equipped to approach a color problem." This statement is unfortunately still valid.<sup>2</sup>

Color is complex and encompasses both subjective and objective phenomena, but there are laws of color just as there are other laws in nature.<sup>3</sup> For a good analogy concerning some of the problems of color, we can consider the entity known as heat. "Heat" is objective and can be measured, but "hot" and "cold" are subjective attributes and cannot be objectively measured.<sup>4</sup> Our perception of color is accepted as subjective,<sup>5-9</sup> and problems in its measurement can be anticipated. In an effort to translate from the physical facts of color, such as measurement of reflectance as a function of wavelength, to the psychologic (i.e., perceptual) facts of color, the science of color measurement (colorimetry) has established an international

psychophysical method of color specification which includes a "standard observer" and standardized light sources<sup>10-12</sup> This approach has supplied an operating base for our attempts to measure objectively this subjective phenomenon.

## 2. Color in Dentistry

### Pigment Colors

Inherent hues of an object.They are inherent in restorative materials (EG.ceramics,composites and acrylic resins.)

- Primary colors
- Secondary colors
- Complementary colors<sup>13</sup>

### Dimensions of Colors

**A) Munsell Color Order System:**The most popular method for describing color is the Munsell system. Despite certain disadvantages, the Munsell system has been widely used in the dental literature<sup>14-15</sup> The three attributes of color in this system are called Hue, Value, and Chroma.

**Hue:** Hue, the first dimension, is the easiest to understand, and in Munsell's<sup>16</sup> words, "it is that quality by which we distinguish one color family from another, as red from yellow, green from blue or purple." The color wheel is a familiar form of this dimension and consists of the Hues that are arranged sequentially around the central axis of the Munsell Color Solid (Plate II, C). To refer to a Hue in the Munsell system, the initials are used: R for red, YR for yellow-red, Y for yellow, and so on.

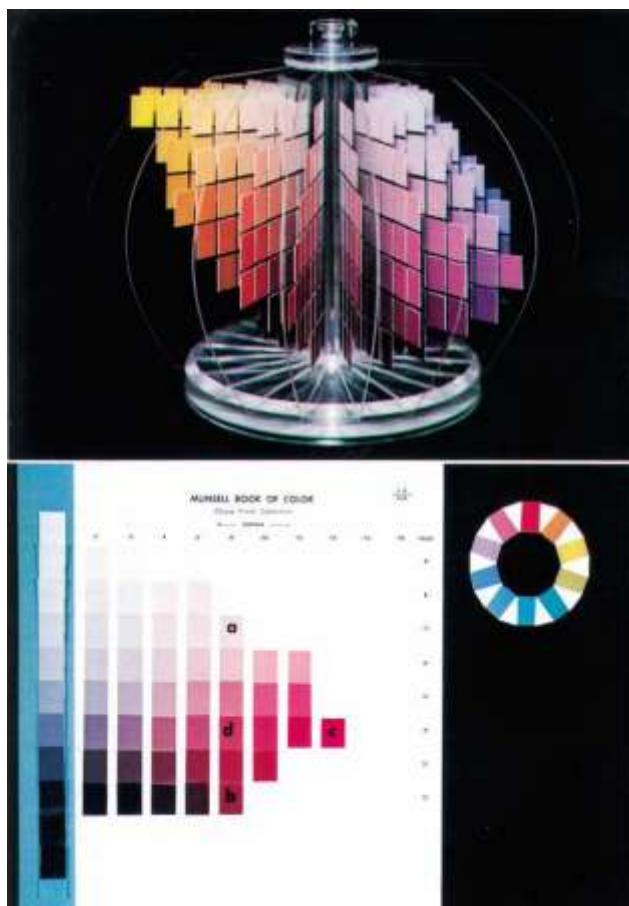


Figure 1

Plate I. The Munsell color tree,  
Plate II. (A) Value scale—theoretical white and black included in addition to the nine Value steps. (B) Munsell Book of Color, C) Color wheel.

**VALUE:** Value “is that quality by which we distinguish a light color from a dark color.”<sup>18</sup> Light energy is measured in photons, and it is possible for objects of different Hues to reflect the same number of photons and thus have the same brightness or Value. This fact created a popular misconception that the Value of a color quantified the amount of grayness. In the Munsell method of describing color, Value is divided into 10 gradations, with 0 being black and 10 being white. Natural teeth range in Value from 5.5 to 8.5 ( Fig 2). A restoration that has too high a Value (is too bright) may be easily detected by an observer and is a common esthetic fault in metal-ceramic prosthodontics.<sup>19</sup>

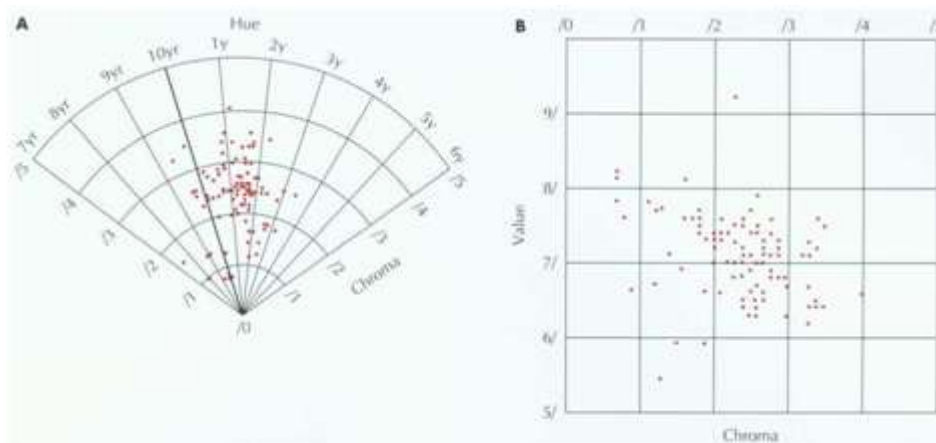
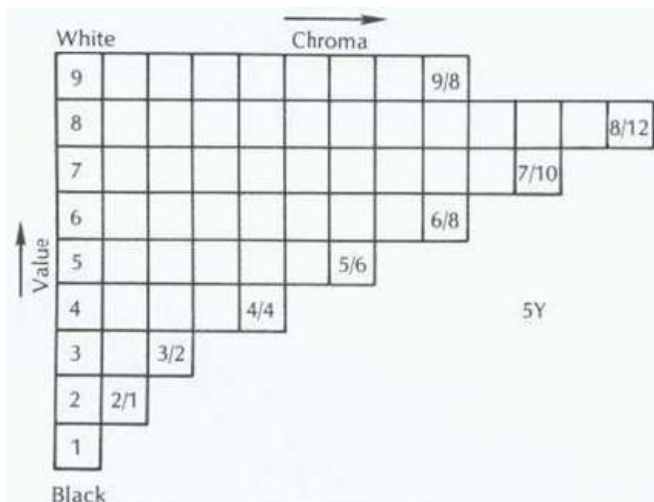


Figure 2: The Munsell plots of the middle third of 95 incisor teeth (A) Munsell Hue and Chroma (B) Munsell Value and Chroma

**Chroma:** Chroma, the remaining dimension, “is that quality by which we distinguish a strong color from a weak one; the departure of a color sensation from that of white or gray; the intensity of a distinctive Hue; color intensity.”<sup>20</sup> In the Munsell color system, maximum Chroma depends on the particular Hue but can range from 10 to 14.

**Achromatic** shades have a Chroma near 0 (Fig.3). Natural teeth are found with Chroma ranges from 0.5 to 4 ( Fig 2).<sup>19</sup>



**Figure 3:** Arrangement of Value and Chroma in the Munsell system

### 3. Identification of Munsell Colors

Munsell<sup>21</sup> explained the system of designating colors in these words: "The notation used in this system places Hue (expressed by an initial, as mentioned earlier) at the left; Value (expressed by a number) above and to the right of the Hue symbol; and Chroma, also expressed by a number, below and to the right of the slanting line." The over-all format in common usage is H V/C. The H is preceded by a number to indicate the precise subdivision of the Hue. The designation for tab a would be 5R 7/8; tab b, 5R 2/8; tab c, 5R 4/14, and tab d, 5R 4/8 (Fig 1 Plate II). Such designations provide an exact identification of a color that is internationally understood

**B) CIELAB system:** When color is measured and specific color differences are identified, the CIELAB system is frequently used. It is a nearly uniform color space whose three coordinates define lightness, red-green chromaticity, and yellow-blue chromaticity. This is the most popular means of defining the color of solid objects and is based on the Commission Internationale de l'Eclairage (CIE) 1976 L\*a\*b\* uniform color space. In 1931 the CIE defined a "standard observer" by a set of three functions  $x(k)y(k),z(k)$ . These were carefully prescribed spectral sensitivity curves designed to model the blue-, green-, and red-sensitive cone receptors of the eye, respectively. These functions are key to the transformation of spectral energy data into meaningful color data.<sup>22</sup>

### 4. Summary

An understanding of the science of color and color perception is crucial to success in the ever-expanding field of esthetic restorative dentistry. Although limitations in materials and techniques may make a perfect color match impossible, a harmonious restoration can almost always be achieved. It is possible to arrange color in a manner that makes this three-dimensional enigma understandable. The Munsell Color Order System is recommended as the system of choice for dentists who wish to gain a working knowledge of color. Once the dimensions of color (Hue, Value, and Chroma) become familiar terms, dentists will have the color language and the necessary tools to approach color matching

problems in a logical manner. This will enable the practitioner to make the best choice and communicate it accurately to the laboratory.

### References

- [1] Clark, E. B.: Seventy-fourth Annual Session of the American Dental Association, Buffalo, N.Y., Sept 15, 1932.
- [2] Sproull R. C.: A Survey of Color Education in the Dental Schools of the World, El Paso, Texas, 1967, U.S. Army Research Report.
- [3] Bond, F.: Color: How to See and Use It, San Francisco, 1954, Camera Craft Publishing Company, p. 7.
- [4] Ronchi, V.: The Nature of Light, Cambridge, Mass., 1970, Harvard University Press, Inc. p. 265.
- [5] Billmeyer, F. W., Jr., and Saltzman, M.: Principles of Color Technology, New York, 1966, John Wiley & Sons, Inc., p. 2.
- [6] Birren, F.: Color: A Survey in Words and Pictures, New Hyde Park, N. Y., 1963, University Books, Inc. pp. 83, 84.
- [7] Judd, D. B. and Wyszecki, G.: Color in Business, Science and Industry, ed. 2, New York, 1963, John Wiley & Sons, Inc., pp. 5, 24-26.
- [8] Aronoff, J., et al.: Psychology Today, Del Mar, Calif., 1970, CRM Books, p. 309.
- [9] Wright, W.D.: The Rays are Not Coloured, New York, 1968, AmericanElsevier Publishing Company, Inc., pp. 2, 19, 20.
- [10] Burnham, R. W., Hanes, R. M., and Bartleson, C. J.: Color: A Guide to Basic Facts and Concepts, New York, 1963, John Wiley & Sons, Inc., pp. 123-150.
- [11] Billmeyer, F. W., Jr., and Saltzman, M.: Principles of Color Technology, New York, 1966, John Wiley & Sons, Inc., pp. 53-89.
- [12] Judd, D. B., and Wyszecki, G.: Color in Business, Science and Industry, ed. 2, New York, 1963, John Wiley & Sons, Inc. pp. 8-71.
- [13] Fundamental of colors-Stephen J. Chu, Alessandro Devisus, Adam J. Meleszko
- [14] Sproull RC: Color matching in dentistry. 11. Practical applications of the organization of color, *J Prosthet Dent* 29:556, 1973.
- [15] Hammad IA, Stein RS: A qualitative study for the bond and color of ceramometals. 11. *J Prosthet Dent* 65:169, 1991.
- [16] Munsell ,A.H.:A Color Notation ,ed.11, Baltimore,1961 Munsell color company,inc.p.20
- [17] Color matching in dentistry. Part I. The three-dimensional nature of color Robert C. Sproull, DDS\* NOVEMBER 2001 JPD p 453-457
- [18] Munsell, A. H.: A Color Notation, ed. 11, Baltimore, 1961, Munsell Color Company, Inc., p. 15.
- [19] Contemporary fixed Prosthodontics third edition Rosensteil.land.fujimoto. p 594
- [20] Munsell, A. H.: A Color Notation, ed. 11, Baltimore, 1961, Munsell Color Company, Inc., p. 16.
- [21] Munsell, A. H.: A Color Notation, ed. 11, Baltimore, 1961, Munsell Color Company, Inc., p. 20.
- [22] CIE. Recommendation on uniform color spaces, color equation, psychometric color terms. Supplementno. 2, CIE Publication no 15 (E-13-1)(tC-1.3). Paris: central de la CIE; 1971.