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Color in Dental Research

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Abstract: Color is considered one of the most important determinants of esthetics in dentistry. Moreover, color is a basic criterion according to which dental materials are classified as esthetic or unesthetic. Unfortunately, color reproduction presents a relatively complex task, unlike the other essential determinants of esthetics (shape, size, and position of a tooth) which are easier to harmonize with the remaining natural teeth. Improper color of a restoration is frustrating to the patient as well as to the dentist. Understanding color requires learning its language. Thus, proper color matching depends on thorough knowledge of the fundamentals of color.

Keywords: *Color order systems; Color perceptibility and acceptability thresholds; Shade selection; Color matching*

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Color is considered one of the most important determinants of esthetics in dentistry **[1]**. Understanding color requires learning its language**[2]**.

Color order systems:

Attempting to communicate colors to somebody else constitutes a major problem. Thus, a number of color order systems had been developed as Munsell color order system and CIE L*a*b* system (Commission Internationale de l'E´clairage) **[3]**.

Munsell color order system describes color in terms of three dimensions; hue, chroma and value. Hue describes the dominant color of an object. Chroma represents the degree of saturation of a particular hue. Value identifies the lightness or darkness of a color **[4]**.

Meanwhile, CIE L*a*b* system has three axes L*, a* and b*. The term (L*) measures the lightness and corresponds to the value in the Munsell color order system, is plotted in the vertical axis. While, a* measures redness (+a*) or greenness (-a*). The b* measures yellowness (+b*) or blueness (-b*). **[5]**

If two points in the L*a*b* color space, representing two measurements, are coincident, the color difference between them will be zero **[4]**. As the distance in color space between the two points increases, the perceived color difference increases **[4]**. One common measure of color difference "ΔE" between two points in the three dimensional color space, is calculated as follows: $\Delta E = [(\Delta L^*) 2 + (\Delta a^*) 2 + (\Delta b^*) 2]1/2$

The term "E" is derived from the German word "Empfindung" which meant "sensation". Therefore, ΔE literally denotes difference in sensation.

The color difference (ΔE_{00}) was measured according to the CIEDE2000. This is the newest color difference formula intended to correct the differences between the measurement result and visual evaluation, which was the weak point in the L*a*b* color space. **[6]**

Color perceptibility and acceptability thresholds:

The mere determination of a color difference between two specimens is of little clinical value without an understanding of the magnitude of color difference that is visually detectable (perceptibility threshold) and the magnitude of difference that constitutes an unacceptable limit to dental esthetics (acceptability threshold). **[7]**

The perceptibility threshold was $\Delta E = 1.2$, $\Delta E_{00} = 0.8$, whereas acceptability threshold was $\Delta E = 2.7$, $\Delta E_{00} = 1.8$ as reported by Paravina RD et al (2015) **[1]**.

Shade selection (Color matching):

a- Visual shade selection:

The visual technique, where the dentist compares the tooth with standard color tooth shade guides, is the most frequently applied method in dentistry as it is cost-effective **[5]**. However, this visual color perception may vary from one individual to another and might even vary for the same individual if the color is measured several times **[5]**.

To avoid these factors, instrumental techniques have been introduced for standardizing shade selection in dentistry **[9]**.

b- Instrumental shade selection:

There are four types of color measuring instruments: tristimulus colorimeters, spectroradiometers, spectrophotometers and digital cameras **[4]**.

Unfortunately, some of these instruments also have disadvantages. "Edge loss" errors occur when measuring translucent specimens because both the illumination and the color measurement make through the same small window in these instruments. Thus, a considerable portion of the light entering the specimen is lost through translucency and scattering and never returns to the sensor for measurement**[10].** Moreover, most of these instruments are designed to measure flat surfaces, while teeth are often not flat, in addition to their high cost. However, most of these problems are overcome by some new instruments **[4, 5]**.

The advanced technology makes the instrumental method the technique of choice for clinical and research based shade selection, as well as for verifying the duplicated shade of the restorations. However, the visual shade selection is still a common method and the combination of both techniques may be beneficial.

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