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SIGNIFICANCE OF COLOR CONCEPT IN DENTISTRY

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ABSTRACT

Esthetics is the science of sensitive perception; in a narrower sense: the science of beauty. According to Encarta encyclopedia (1997) esthetics is a branch of philosophy concerned with the essence and perception of beauty and ugliness. The first signs of man's interest in the facial beauty were recorded more than 4000 years ago. Facial masks of "ideal" shape and proportions used to be the hallmark of royalty even in the ancient Egypt as far as from 2600 to 2000 BC (Mack, 1996). Shape and proportion, however, are not self-sufficient and they are not the only parameters of beauty. Modern concepts of esthetics in dentistry analyze this issue using a much wider approach. The present review article discusses the role of color in dentistry.

INTRODUCTION

A German philosopher Baumgartner 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 [1, 2].

Lombardi (1973) described principles of visual perception and their clinical application to denture esthetics. When the term "esthetic" or "unaesthetic" is used it usually means that something is perceived as pleasant or unpleasant. The observer's response to physical stimuli is, in fact, his/her psychological and physiological interpretation of that what he/she perceived. The stimulus, i.e. the observed object on one hand and the response to that stimulus on the other are the elements of the science of visual perception [3].

There is a lot of perplexity and confusion just as there are numerous insufficiently explained questions in shade matching and reproduction procedures. However, it is neither easy nor simple to answer these questions. In spite of objective and subjective inadequacies of the shade matching and reproduction method itself, dental material manufacturers could be blamed for certain problems in this area. The problem is that the majority of dental color standards lack a logical sample arrangement order and adequate color distribution; moreover, they do not match natural teeth color range. Since natural tooth color is not uniform, harmonization of shade guide samples, dental materials and prefabricated artificial teeth color composition with the color composition of natural teeth emerges as a yet unresolved issue.

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COLOR SCIENCE

A need to overcome subjectivity, as the major disadvantage of the visual shade matching method, induced the evolution of color science. In order to understand the science of color, one should be aware of some physical aspects of light, as well as of both physiological and psychological processes that enable color perception. Webster defines color as "the sensation resulting from stimulation of the retina of the eye by light waves of certain lengths [4, 5]

COLOR MATCHING METHOD

It is more than obvious that it is not simple to provide adequate shade matching conditions. As for the shade matching method, there have been significant improvements in this area, especially in the last ten years.

Shade matching should be performed at the beginning of the appointment and the patient's mouth should be at the level of the dentist's eye [6]. A shade guide sample should be applied parallel with the tooth whose shade is being matched, not in front of it, for it will appear lighter, not behind it because it will appear darker. Some authors suggest that the cervical part of samples should be removed because they are more saturated, which could have a negative effect on the shade matching [7]. Spencer suggests removal of the mesial and the distal third of the samples in order to enable application of two shade guide samples next to the tooth whose color is being matched.

If the sample and the tooth whose color is being matched have different surface texture, both should be wet, in order to neutralize this difference. Tooth should not be observed for more than five seconds at a time, and, in the meantime, it is desirable to observe some blue surface for one minute [8] in order to increase the ability to differentiate yellow color (the dominant color of the teeth). Owing to possible occurrence of metamerism, the choice should be verified under different illuminants. Some authors' attitude [9, 10], that esthetics can be improved if the dentist and the dental technician use shade guides and relative porcelains of several manufacturers is logical and acceptable. It is also suggested that extended shade guides should be used (containing the samples of all ceramic masses used for the production of PFM restorations), such as Vita "VMK - Shade Indicator".

MUNSELL COLOR ORDER SYSTEM

Many color order systems are available, but for a variety of reasons, including worldwide recognition, consistency, flexibility, and simplicity, the Munsell Color Order System is the system of choice for color matching in dentistry [11].

The color tree (Plate I) is a representation of the tridimensional organization of the colors within the Munsell System. Colors (Hue) are arranged around this axis, and within each Hue, the colors are arranged in scales according to their lightness/darkness (Value) and their purity or strength (Chroma).

Light colors are toward the top of the cylinder; dark colors are toward the bottom. The colors are purest on the outer skin of the cylinder and they become progressively grayer as they approach the gray Value axis. Within each of these scales of Hue, Value, and Chroma, the intervals were chosen to represent equal visual spacing under a standard light source. Value and Chroma are more difficult to understand and are often confused with one another. Special attention must be focused on these dimensions.

Value: Value "is that quality by which we distinguish a light color from a dark color", and this is related to the achromatic (colorless) polar axis going through the Munsell color solid. The value of a color is determined by which gray on the Value scale it matches in lightness/darkness.The black of the Value scale is assigned a Value of zero, the white a Value of 10. An infinite number of gradations of gray are possible as we go from black to white, but only nine Value (gray) steps are used in the Munsell system. Pure white (10) and pure black (0) are unattainable. Fractional numbers are used when a finer evaluation is needed. "Low" values refer to dark colors: "high" values to light colors.

We perceive Value differences when we watch a black and white television picture. The actual scene is full of color, but only the lightness/darkness (Value) of a color is transmitted, a blue, red or yellow could all be transmitted as the same indistinguishable gray if they are of the same Value (a part of the same Value "wheel'). Colors of high Value would be transmitted as light grays, and those of low Value as dark grays, regardless of the Hue or chroma. It could be said that the Value of a color is the gray it would match if it were seen on a black and white television screen.

Chroma: It 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. Chroma describes the amount of Hue in a color. The gradations of Chroma were referred to as the spokes of our wheels. The concept of painting a box will help to clarify this dimension. Suppose it is desired to paint one side of box pure red. If an amount of gray paint is added to the bucket before the second side is painted, the red on the second side will be perceived as less than a pure red; the Chroma will be reduced. If additional gray paint is added to the bucket before each additional side is painted, the paint will come closer and closer to being perceived as a gray.

The need to refer to gray in describing both Value and Chroma is a major factor in the confusion concerning these two dimensions. To think of Value in relation to the television picture and Chroma in relation to the painting of the box will provide a simple, easily recalled memory aid.

SHADE SELECTION PROCEDURE

Dentists have had little or no training in vision physiology or color science. The increase in newer types of ceramic restorations and the improving quality of esthetics means the dentist of the 21st century must be trained to detect differences in color and shades in individual teeth, select a shade that reflects the color and exact shade, transmit this information to a dental technician, and then be able to make any necessary adjustments to the restoration [12].

TOOTH COMPARED WITH PORCELAIN

Prior to shade matching, the dentist must have an understanding that the human tooth and dental porcelain transmit light waves differently. It is their physical composition that determines the differences in light-wave transmission, absorption, reflection, refraction, scattering and surface gloss. The manner in which light strikes an object determines the total appearance of the material.

Transparent materials allow for the passage of light with little change. Translucent materials scatter, transmit and absorb light. Opaque materials reflect and absorb; however they do not transmit. Surface characteristics, such as gloss, curvature and texture, will affect the degree of light diffusion when striking the particular object. A vital tooth is both naturally translucent and transparent. Enamel rods are transparent and therefore refract and reflect light. Light that strikes the incisal edges of an anterior tooth passes through with maximum transmission because of a high degree of translucency [13].

Porcelain, however, is a heterogeneous material. It contains transparent properties and metallic oxides that act as opacifiers. These porcelains modify light by absorption, transmission and reflection. Absorption is largely responsible for color. It occurs when light passes through the layers of the porcelain. Scattering occurs when light encounters interfaces between the materials (i.e., pigments and glass). The smaller the pigment size, the less light that is absorbed, resulting in less detectable color. The larger the pigment size, the more reflection that occurs as light scatters at the particle surfaces. Scattering light is necessary in dental porcelains to simulate the prismatic effect of enamel. Yet, one must keep in mind that too much dispersed reflection through internal scattering will create an unnatural looking prosthesis.

LIGHT SOURCES

One of the questions asked when selecting a shade is, what light source should be used? Shade determination should be performed under color corrected fluorescent lighting, which contains a balance of the entire visible spectrum. The operatory should be lit using a luminous ceiling with translucent diffusing panels that are simple to maintain. Clean watt saver lamps having a color temperature of 4200K or higher is advocated. Shade selection should not be made using daylight, because daylight is subject to constant changes. One must also be concerned with the phenomenon of metamerism, which occurs when the color of two objects looks identical when observed under one light source but different under other light conditions. Metamerism occurs only when two objects have different wavelength distribution and therefore reflect different spectra.

The color of the operatory can also affect shade selection. Colors should be kept at a low saturation level. Walls and cabinets should be glossy enough to maintain brightness without causing a glare. It is recommended that the color of the walls and ceiling be white or off-white. The dentist should be concerned with "blue fatigue:' this occurs when the eye is unable to differentiate between the various shades of blue. However, blue fatigue increases sensitivity to yellow therefore, to improve shade selection in the yellow range, the operator should stare at a blue card or patient napkin between shade comparisons. It has been suggested that dentists use natural north daylight for shade matching. Many dental offices have been designed to face the north to enhance the selection process. However, daylight is not at a constant throughout the day and therefore must not be used as the only light source for shade matching.

THE PROBLEM WITH SHADE GUIDES

Shade guides have become the standard for selecting shade, yet there have been many errors associated with the use of commercial shade guides. Problems that may arise include the following:

1. Porcelains do not match the shade guides that they are being compared to.
2. Shade variations occur between different die lots of porcelain from the same manufacturer.
3. Shade guide tabs are 4-5 mm thick compared to the thin 1.5 mm piece of porcelain used for the restoration.
4. Shade guides are not always made with fluorescent porcelain, which causes inconsistencies in color matching.
5. It is difficult to predict the final shade after the layering of opaque, dentin and enamel.
6. Guide tabs lack a metal backing when using porcelain-fused to-metal restorations.
7. Shade tabs are condensed differently than porcelain used for final restorations.

Now that the reader understands the potential problems that arise when selecting shade, it is imperative that the dentist have a proper education in color. However, we must assume that not every dentist will seek out the proper courses. The latter portion of this article will be a review of numerous methods for enhancing laboratory communication between the dentist and the dental technician, to assure the success of proper shade matching. The dentist must then decide for himself or herself how much information is enough to guarantee the replication of the restored teeth [13].

SHADE SELECTION GUIDELINES

There are a number of methods that can be employed to intensify the shade selection:

1. If patient is wearing bright clothing, drape him or her with a neutral colored cover.
2. Have patient remove lipstick or other make-up.
3. Clean the teeth and remove all stains and debris.
4. Have patient's mouth at dentist's eye level.
5. Determine shade at the beginning of the appointment to avoid ocular fatigue.
6. Shade comparisons should be performed at five-second intervals so as not to fatigue the cone cells of the retina.
7. Obtain value levels by squinting.
8. Compare shade under varying conditions (i.e., wet vs. dry lips; retracted lip vs. pulled down lip).
9. Use the canine as a reference for shade because of the highest chroma of the dominant hue of the teeth."
10. If unable to precisely match shade, select a shade of lower chroma and higher value.
11. Grind off the necks of the shade tabs because they tend to be darker than the rest of the shade tab [14].

CUSTOM SHADE GUIDES

To properly start the shade matching process the dentist should acquire a custom shade guide. This guide is the beginning of improving communication with the laboratory each custom shade guide should include the ceramist's metal, porcelain, staining kits, equipment and techniques. It should also contain pointers as to what to look for when selecting a shade. The technician needs to send a chart along with the guide for jotting down any additional information that will allow for a better understanding of the particular shade. The dentist may choose to create a luster tab and send it to the laboratory with the prescription. The technician will then have a visual aid for what he must fabricate. Numerous techniques regarding custom shade guides have been noted in the literature.

PROCEDURE FOR SHADE SELECTION

The first step is to select the hue. This is a delicate step since there is not much difference among the hues because different chromes of the same hue are close to each other in the manufacturers arrangement of the shade guide there can be confusion. When the canine is present, it is the best tooth on which to choose hue because it has the highest chroma. This step should be performed within 5 sec; otherwise the ability to recognize the desired hue decreases. The eyes are then rested by gazing at a blue background.

The second shade guide arranged according to the value, is used to select the value. An important part of this procedure is to squint the eyes. Squinting causes the black and white sensitive rods in the eye to become more active than the color sensitive cones. The rods are responsible for helping to determine the value. It is important to avoid consideration of the hue and chroma when selecting the value. The value that has been selected is used to choose the opaque porcelain. If the value is wrong, the effect will be particularly unpleasant in the cervical region where the thickness of PFM is less.

CONCLUSION

The increase in newer types of ceramic restorations and the improving quality of esthetics means the dentist of the 21st century must be trained to detect differences in color and shades in individual teeth, select a shade that reflects the color and exact shade, transmit this information to a dental technician, and then be able to make any necessary adjustments to the restoration. However, there are a number of factors that stand in the way of properly selecting a color match. Subjective faults range from differences in color perception to ocular fatigue and lack of education regarding the basic principles of color. Metamerism may occur if proper lighting is not used during shade selection in the dental office and laboratory finally, existing shade guides are limited and require a more extensive range of shades.

Errors in shade matching continue to be a problem and a source of dissatisfaction for the patient. In spite of the limitations in materials and techniques a harmonious restoration can almost always be achieved if a methodical and organized manner is followed during shade selection.

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