Society for Color and Appearance in Dentistry

clinical relevance for researchers & scientific relevance for clinicians

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Dental Color Matcher

An Online Educational and Training Program for Esthetic Dentistry

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The importance of color in esthetic dentistry

We're experiencing a boom in esthetic and cosmetic dentistry. According to a survey by the American Academy of Cosmetic Dentistry, virtually everyone believes a smile is an important social asset. Three-quarters of adults feel an unattractive smile can hurt a person's chances for career success.

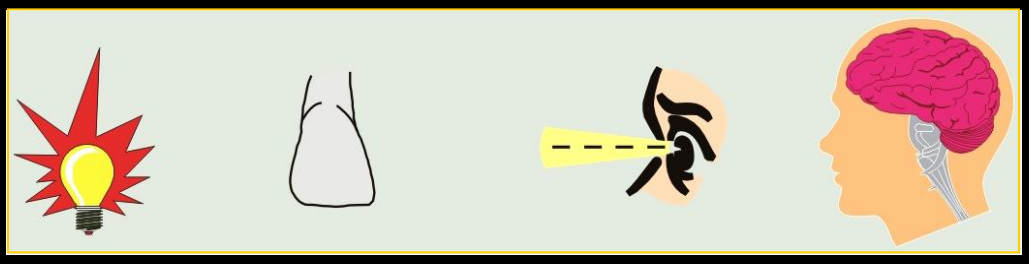
When asked "what is the first thing you notice in a person's smile?" participants listed straightness, whiteness and color of teeth. On the other hand, discolored, yellow, or stained teeth were identified as characteristics that make a smile unattractive. When participants were asked what they would most like to improve about their smile, the top two desires were whiter and brighter teeth. Probably the best description of the importance of color in dentistry was offered by Dr. Stephan Bergen, one of the pioneers of esthetic dentistry: "Color is unimportant to the physiologic success of a dental restoration, yet it could be the controlling factor in the overall acceptance by the patient."

Are we gifted for shade matching?

In reality, we are not as good in shade matching as we would like to believe. When asked to match pairs of tabs from two Classical shade guides, participants correctly matched only 50% (8 out of 16 pairs). We should keep in mind that this test was much easier than in real-life dentistry, where the exact match rarely exists! When the color of natural teeth was matched using three different shade guides, the clinical acceptability of custom-made ceramic tabs made of appropriate dental ceramics ranged from 40-57%. In other words, up to 60% of tabs were clinically unacceptable.

What is color?

Color is a psychophysical sensation produced in the eye by visible light and interpreted by the brain. So we are talking about the color triplet: light source, object and observer.



Color triplet: light, object, observer (eye and brain)

A light source is any area or body that emits radiation in the visible spectra range. Some standard light sources are designated as A or incandescent, B, C, and D or daylight. Daylight is further subdivided/categorized as D50, D55, D65 and D75).

The object reflects, absorbs or transmits light. What we actually see is the reflected portion of light.

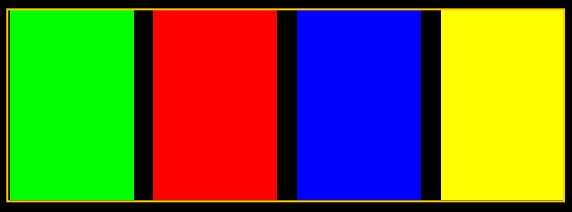
The observer is the third part of the triplet. All visual sensations are brought to the brain through the eye. The retina has two types of nerve endings, rods and cones, and these enable color perception. Rods only record light—in other words, they see in black and white. Cones enable color vision. The three types of cones are blue, green, and red-sensitive. Visual information from the eye is then relayed to the brain where the messages from the rods and cones are interpreted.

Dimensions of color

Color is a three-dimensional phenomenon. The names of the color dimensions are hue, value (lightness) and chroma.

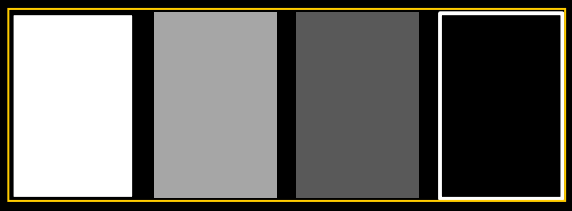
Color is a three-dimensional phenomenon

Hue is a dimension that enables differentiation between "color families". For example, red, green, blue, yellow. Hues are placed in a closed hue circle that encompasses 360°.



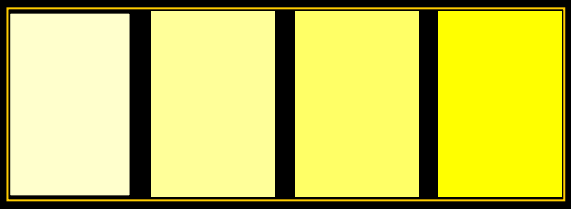
Hue: color families; color name

Value or lightness, is a dimension that enables differentiation between light and dark colors. Value is represented as a vertical axis - pure black at the bottom and pure white at the top, with all the shades of gray in between.



Value: white to black; achromatic

Chroma is a color dimension that allows differentiation between pale and strong, weak and chromatic, that is, washed out and saturated colors. Chroma is represented as the distance from the vertical, or achromatic, axis.



Chroma: pale to strong; washed out to chromatic

Color of human teeth

Human teeth can be described as predominantly light, whitish-yellowish and slightly reddish. They are small and curved, with color transitions from cervical to incisal, mesial to distal, and labial-buccal to lingual. They also have variety in the thickness and translucency or opacity of the enamel and dentin. Local color characteristics, such as enamel cracks and craze lines, enamel hypoplasia, fluorosis, tetracycline staining or incisal halo, will add additional complexity to tooth color matching, communication and reproduction.

Color matching methods

Tooth color can be matched or measured by visual comparison or by utilizing shade matching instruments. Visual comparison with dental shade guides, although widely used, is subjective and to a certain extent inconsistent. Hand-held color measuring devices are objective and very helpful, but they are not widely used. Results of instrumental measurements are frequently given in corresponding shade tabs, while color differences are numerically expressed in ΔE units, which represent the interaction of hue, value and chroma differences.

Easyshade Compact, a shade matching instrument

Dental shade guides

The primary requirements for good dental shade guides are logical order and adequate distribution within the tooth color space.

Three basic conceptions of dental shade guides are currently present:

- Vitapan Classical and Classical-keyed products, which have an empirical conception
- VITA 3D-Master shade guides, which are evidence-based and scientifically grounded
- Others, which are proprietary conceptions.

Vitapan Classical has been available since 1956, which probably makes it the most resilient dental product on the market. It was, and to a certain extent still is, a gold standard for shade matching in dentistry. The vast majority of resin composites are keyed to the Classical. However, the primary requirements, logical order and adequate color distribution, have frequently been listed as concerns related to the Classical.

Two tab arrangements are utilized for the Vitapan Classical:

The *A to D arrangement* encompasses four groups based on hue: A is red, B is yellow, C is gray, and D is reddish-gray. Within the groups, higher numbers correspond to higher chroma.

Vitapan Classical, A to D arrangement

The *value scale* represents a light to dark arrangement, from B1 (shade 1) to C4 (shade 16). The value scale is frequently used for visual monitoring of bleaching efficacy, which is expressed in shade guide units, or SGU. The SGU equals shade number (1-16) before bleaching minus the shade number after bleaching. Inconsistencies in the Classical value scale compromise findings to a certain extent.

Vitapan Classical, value scale

There are three VITA 3-D Master shade guides: Toothguide, Linearguide and Bleachedguide. All 3D-Master shade guides have been developed based on research. According to the literature, they match the color range and distribution of human teeth the best, which means that the probability of selecting a good match will be the highest with these products.

Toothguide was the first 3D-Master shade guide. Each 3D-Master tab is marked using a number-letter-number combination. The first number designates the group and represents value, with 0 as the lightest and 5 the darkest. The letter represents hue, with the letter L corresponding to yellowish, M to medium and R to a reddish hue. The final number represents chroma, with 1 being the least chromatic, through 1.5, 2, 2.5, to 3 as the most chromatic.

Toothguide 3D-Master

Shade matching with the Toothguide requires three steps. In the first step, the lightness is determined using all tabs and the number of possible shades is reduced from a total of 29 to 2 tabs (if group 1 is selected), 3 tabs (if groups 0 or 5 are selected), or 7 tabs (if groups 2, 3 or 4 are selected). In two separate subsequent steps, chroma and hue are determined. This method can be challenging for those with little experience in tooth shade matching or with little knowledge about the physical background of the system.

Linearguide 3D-Master has the same shade tabs as the Toothguide. The difference is in its design, and in its reduction of shade matching to only two steps.

A single linear scale that contains only the middle tabs from each group (0M2 to 5M2), is used in the first step. A small number of tabs with huge color differences and the familiar linear tab arrangement simplify the initial selection.

Linearguide 3D-Master, step 1: group selection

The second step is “fine tuning” within the group selected in step one, 0-1, 2, 3, 4, or 5. Many users describe the shade matching method with Linearguide as self-explanatory and user-friendly, which is the reason it is used in the Dental Color Matcher program.

Linearguide 3D-Master, step 2:
selection within the group

Bleachedguide 3D-Master is the first shade guide developed specifically for visual evaluation of tooth whitening. Whitening causes a decrease in chroma and an increase in lightness of natural teeth. With millions of people bleaching their teeth every year, the development of an adequate shade guide was greatly needed. Bleachedguide exhibits a wider color range and a more consistent color distribution, when compared to the Classical and some other products. Inclusion of very light shades complements contemporary esthetic dentistry.

Bleachedguide 3D-Master

Who is better: females or males, experienced practitioners/specialists or a novice?

The shade matching abilities of color-normal men and women are equal. Normal color vision, not gender, should be the criterion for choosing the person to perform shade matching. The color vision test, similar to the simulation given in our program, should be routinely administered to dental students and professionals. Color deficiency is a weakness or absence in one or more cone systems. Approximately 8% of males, that is 1 in 12 males, and 0.5% of females, or one in 200 females, are color deficient. Please note that color deficient people are not "color blind".

Computer simulation of normal color vision (left) and different types of color deficiency

The literature is equivocal on the question of whether experience, that is years in practice, affects shade-matching ability. Experience is relevant, but so is the status and age of the visual organ.

Can shade matching skills improve?

When it comes to color education and training, we should not forget, as James Michener once said, “An age is called Dark, not because the light fails to shine, but because people refuse to see it.”

Research on three educational and training programs to improve dentists’ color matching skills found that color matching results can be improved. Unfortunately, color education and training are not part of every dental or post-graduate curriculum. By taking the Dental Color Matcher program, you are helping to correct this shortcoming.

Shade matching conditions

Light and environment are key factors in shade matching. Ceiling light or portable light, that is, floor-, table-, or hand-held light, can be used for work with color in dentistry. When buying lamps for shade matching and reproduction in the office and lab, you should look for diffuse color corrected light, D65, D55 or similar, with a color rendering index (CRI) of 90 or greater. If this sounds complicated, ask the sales person or customer support for assistance. The recommended light intensity is one 1000-1500 lux. Although the oral cavity is the background for shade matching, the immediate surroundings, such as the patient bib and office surroundings, would ideally be light gray.

Please note that this does not mean that we should have uniform and boring light gray offices and dental labs. A designated light-gray shade matching and reproduction area will be sufficient.

If portable lamps are used for shade matching, the influence of surrounding colors will be significantly reduced, especially if the ceiling light is off. If diffuse illumination is coming from the ceiling, do not forget that the patient's nose can make a shadow. A 45° angle, one- or two-directional, is recommended for floor and table light, while the viewing angle should be at 0° degrees. A 0° lighting with a 45° viewing angle is also appropriate for table light. Hand-held lights usually come with instructions on the positioning, distance and method.

Hand-held shade matching lights

A simple step-by-step outline for shade matching

Shade matching should be done by dental professionals having normal color vision. Color-deficient persons should be assisted. Tinted contact lenses/glasses should not be worn during shade matching.

Shade matching should be done by dental professionals having normal color vision

First, clean the tooth whose color is to be matched, and ask your patient to remove any lipstick. If a cheek retractor is used, a clear one is preferred.

Shade matching should be performed at the beginning of the appointment. Both the dentist's eye-fatigue and the patient's tooth color alteration could occur during the appointment.

Observe the tooth perpendicular to its labial surface and align your eyes on the same level with the teeth. Shade matching distance should be 25-35 cm, or 10-14 inches.

Whenever possible, place the shade tabs on the same plane and with the same relative edge position as the tooth to be matched. The tab carrier should be along the tab's normal axis. When the adjacent tooth is present, tabs can be placed horizontally or vertically in between the upper and lower teeth.

A single shade matching trial should last no more than five seconds at a time. Observe a neutral gray card between trials.

The tab and the tooth should be wet with water in order to neutralize surface texture differences.

Reduce the number of potential matches as quickly as possible. Separate them from the other tabs and choose the closest one or combination of shade tabs.

Color matching method

Translucency, gloss, surface roughness, and local color characteristics should be visualized and documented on a lab prescription.

It's always good to verify your selection under different illuminants and different angles in order to avoid or reduce metamerism. Metamerism occurs when two colored samples appear to match under one condition but not under another.

Color matching is a comparison of our overall impression of observed objects. In other words, we cannot see lightness, chroma and hue separately. During color comparison, we see differences, not similarities, among colors. Although we can see differences in lightness, chroma and hue during tooth shade matching, these differences are mixed in a wide variety of ratios. It is quite easy, for example, to confuse an increase in chroma with a decrease in lightness. The example that all dental professionals are familiar with are A1 and B1 shades of Vitapan Classical. While B1 is considered to be the lightest shade in Classical, A1 actually has a higher value. B1 appears lighter because it is less chromatic! Therefore, frequently the best approach is simply to match the color and the best shade matching advice is SELECT THE BEST MATCH! When you must perform a dimension by dimension color matching technique, the most appropriate order would be value-chroma-hue.

Once the shade is selected and agreed upon by the patient, use a high quality digital camera to take photos of the tooth and the selected shade tab aligned next to each other. In addition to keeping these pictures in the patient's record, they are very important for communication about colors. Inclusion of verbal and written instructions and custom made or modified shade tabs is very beneficial. Digital imaging enables an immediate outcome to be shared instantly by the internet, email, CD-ROM, or a storage device.

Communication: digital imaging

Material-related aspect of color reproduction

Color reproduction is a combination of dental art and science. This is a topic that would require a great deal of time and space to be addressed. In a nutshell, esthetic dental materials have undergone amazing improvements related to optical properties during the last decade. Materials are now available that exhibit:

- outstanding color compatibility with natural teeth
- excellent color stability during fabrication, at placement, and after placement
- color interactions that could reduce color mismatch, such as blending and layering

However, we can still experience the of "same hand, different outcome" situation, based solely on material selection. Therefore, material selection can be a critical component for the success of a dental restoration. It requires frequent updates from professional publications, information from manufacturers, and other sources.

The future

What does the future hold? Chances are good that new, improved and color-stable materials, that correspond to the color of human teeth and exhibit pronounced blending, will contribute to successful work with color and esthetic dentistry in general.

Educated and trained dental professionals, along with affordable high-quality color matching instruments, will certainly contribute to this goal. Simply stated, the future of color and esthetic dentistry looks light and bright!

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