Clinical Feature

Perceptions of Colour

Our ability to perceive colour is a critical component in esthetic and restorative dentistry, but few individuals have had their colour vision tested. A study at the University of Tennessee’s College of Dentistry looked at 150 dental students and found that 9.3 percent of the men and none of the women exhibited a colour vision defect.¹ This correlates to the existing medical data for the general population. When comparing men and women without colour vision defects, men as a group show more uniform shade selection than women.² Our ability to perceive colour and visual acuity is also affected by aging.³,⁴ Over time, the cornea and lens of the eye become yellowed, and after the age of 60 blues and purples are significantly affected. Chronic illnesses such as diabetes can create sensitivity to red and green. Glaucoma decreases sensitivity to blue, green and yellow. Medications can play havoc with our colour perception. Oral contraceptives cause red-green or yellow-blue discrimination defects. Other medications that can affect colour vision include ibuprofen, anti-epileptic drugs,⁵ Aspirin and antibiotics such as amoxicillin, lidocaine, Viagra and Zantac. Some of the above factors may influence not only the practitioner, but staff as well, as all humans suffer from some level of colour vision confusion.⁶ Therefore, it seems prudent that when choosing a colour, the team approach is indicated to minimize the personal variables. The author has also found that involving dental office personnel in this process creates a sense of ownership in the procedures being performed, as well as a sense of achievement in the patient’s well-being when the restorations are a clinical success.

Effect of Surroundings

The impact of office colour as it relates to psychological effects was discussed in an article in the November issue of Ontario Dentist.⁷ However this article failed to note that our colour perception is affected by the reflection, or interference from, surrounding colours. It is critical therefore to have a neutral background colour. We must also neutralize the effects of clothing, make-up, and especially lipstick. It has often been stated that since our eyes can be fooled into seeing colours differently by surroundings, one should stare at a tooth for less than five seconds because our eyes become accommodated to the colours of red and yellow.⁸ To reduce the after-image which occurs when looking continuously at an object of one colour, a common recommendation is to look at a blue object (such as the patient’s bib) between assessing different shade tabs. Blue backgrounds, however, are not appropri-
ate because they also cause after images and will bias your perception to its complementary colour orange. The eyes should be given a break with a neutral grey background such as a Pensler Shield (Kulzer), which is designed to screen out background colour glare. I feel it should be used every time a tooth shade is taken. It is important to ‘correct’ our eyes when assessing shades so that our interpretation of the colour not be biased by the after-image.

**Characteristics of Natural Teeth**

Teeth vary in colour due to age, and their differences are summarized below:

**Young Enamel**
- is less translucent
- obscures dentin
- has a high value
- has minimum translucency
- presents a bright appearance.

**Older Enamel**
- has a low value
- has a dull appearance
- has maximum translucency
- permits the lower value of dentin to come into view

The subtleties of colour, translucency, discrete staining, texture, luster and shape are all essential features. Each tooth is unique and has factors that affect its colour. These include the colour of the dentin, enamel, their combination and the way light is absorbed or reflected.

Natural surface texturing can have a major effect on colour. Surface gloss refers to the ability of the tooth to absorb or reflect light and surface texture refers to the degree of smoothness versus variations or ridges that occur on the surface. These surface characteristics affect the value or brightness of the tooth and are almost never communicated to the laboratory or incorporated into a direct restoration.

**Colour: Three Components**

There are three critical elements to consider when discussing colour:
- **Hue** – the quality distinguishing one colour from another, (i.e. red, blue, green etc).
- **Chroma** – the saturation or intensity of a specific colour
- **Value** – or brightness: the amount of light that is reflected from an object

**Value is the most important dimension of colour**

when it comes to shade matching with its control being of paramount importance in achieving a vital, life-like appearance that is in harmony with the surrounding dentition. We notice value in preference to hue because our eyes use approximately 120 million receptor rods to judge
light value versus six-seven million cone-shaped receptors to distinguish hue, a factor of $20^8$. Arrange the Vita classic shade guide into the critical value-oriented sequence (B1, A1, B2, D2, A2, C1, C2, D4, A3, D3, B3, A3.5, B4, C3, A4, C4), to quickly focus on the correct value first, and then the hue (colour) second. Remember that shade tabs are darkened over time by cold sterilization procedures commonly practised today and should be replaced yearly.

**Light Quality**

The most influential factor when determining tooth shade is the quality of the light source.$^{13}$ A frequent recommendation in the dental literature is to take shades in daylight at mid-day (Figure 1), but this light can vary tremendously depending on weather conditions, time of year and global positioning. Dental unit lights are usually incandescent lights that emit light high in the red-yellow spectrum and are low at the blue end. Regular cool white fluorescent lights are high in the green-yellow spectrum with some large variations in the other colour spectrums. Colour-corrected fluorescent lights are available which render the colour more accurately.”$^{9}$ (Figure 2). One can see in Figure 2 that even with these types of colour-corrected fluorescent lights, there are drastic variations in the colour spectrum from daylight. The diffuser, which usually covers the ceiling fixture for a bank of fluorescent lights changes with time, and also modifies and inhibits the light output. If these types of fluorescent bulbs are used, an egg crate diffuser rather than a covering lens is recommended. Fluorescent light bulbs also denature with time from the moment they are installed, so one is never quite sure of the spectrum output. Exact shade selection and reproduction is impossible without a full colour spectrum light source. Full spectrum light emitting diodes (LEDs) are now replacing incandescent bulbs.$^{14}$

Shade matching ability is better with a light-correcting source than under natural light.$^{15}$ A new device to help eliminate the variability of different light sources has recently been introduced to the dental marketplace. The Optilume Trueshade (Clinical Research Dental) which uses full spectrum light emitting diodes, shows a colour spectrum very similar to mid-day daylight (Figure 3). Diffusion lenses over the LEDs mix the three (RGB) colours of light emitted by the individual colour diodes to create optimum, diffuse daylight. With the LEDs set at a 45-degree angle to minimize spectral reflectance or glare, the clinician can more accurately assess the true colour (Figure 4). The difference in colour rendering of teeth is readily apparent in Figure 5 taken under artificial light versus a photo of the same teeth (Figure 6) taken with the Optilume Trueshade. The Trueshade has a 5500 degree K light temperature, ideal for colour rendering. By incorporating a 2X magnification BK7 optical quality crown glass the Trueshade permits the oral site to be magnified and allows for detail to become more visible. A unique feature is the ability to reduce the intensity of the light source while maintaining the colour temperature. A lower intensity light allows for better perception of surface detail such as topography, ridges and enamel striations which affect the value, so that these can be reproduced.

To take a shade, the shade tab is held in the area to be evaluated, as per normal practice, with the Trueshade held about five cm from the patient’s face (Figure 7). Digital photography can be taken through the Trueshade for a better colour rendering of the clinical circumstances if shade communication needs to be sent to the laboratory.  

![Figure 1.](image1.png)

Wavelength (nm)

Spectral radiance (microW/m²)

Wavelength and spectral radiance of daylight at midday.

![Figure 2.](image2.png)

Wavelength (nm)

Spectral radiance (microW/m²)

Wavelength and spectral radiance of daylight fluorescent tube – note drastic variation from Figure 1.

![Figure 3.](image3.png)

Trueshade colour spectrum.
Hints for Shade Selection

1. Always take a shade at the beginning of the procedure, before tooth dehydration can occur.
2. Modify your shade tabs by removing the gingival collar, which is usually darker than the body.
3. Match with the shade tab incisal to incisal and then focus on the mid body.
4. Document your colours with digital photography. Take pre-operative photographs and also photograph the shade of the prepared tooth, if it is drastically different or a shade modification is necessary.
5. The chair light should be turned off — it emits a yellow colour.
6. Arrange the shade tabs by value. This allows a quick left-to-right scan to focus on the correct value first.
7. Between colour tabs “normalize” your eyes by looking at a grey shield, not a blue or purple bib.
8. Select shades as a team to neutralize individual colour perceptions and variations.
9. Look at the teeth under low light to highlight the surface characteristics that may affect the value.
10. Communicate subtle highlights of colour, areas of translucency and internal lobe form, if it shows through the enamel.
11. Photograph the teeth with the closest shade tab, if the case is being sent out.
12. Take photographs at 45 degree and 90 degree angles to pick up subtle colour characterizations and surface detail.
13. For direct esthetic restorations create a pre-operative colour map, and do not deviate from it as the adjacent teeth begin to dehydrate and change colour.
14. Give your laboratory written details on surface texture — smooth or characterized, minimal, moderate or heavy.
15. For background, use an 18 percent reflective grey card to isolate the tooth and minimize surrounding colour effects.
16. Use a light source with a complete colour spectrum to optimize colour selection.

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DISCLOSURE
Dr. Boksman is the Director of Clinical Affairs for Clinical Research Dental Inc.

References