

# Shade selection

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*“Correct shade selection is essential in the provision of aesthetic restorations. Understanding the influence of different variables in shade selection from light illumination to the tooth’s hue, value and chroma and how the eye interprets this can assist in this selection...”*

**S**hade selection is an important procedure to provide patients with an aesthetic restoration that harmoniously blends to the patient’s existing dentition. Knowledge of the scientific basis of colour from understanding light to also interpreting the artistic aspects of shade selection ensures a successful result.

Shade selection involves the perception of colour, which depends on three entities:

1. Light source (illuminant);
2. Object; and
3. Detector (ocular or instrumental).

The visual system of the eye is only capable of detecting wavelengths from 380 (violet) to 780nm (red). Isaac Newton showed that light had no colour, as it is only when it interacts with an object that colour is produced (Figure 1).

## Illuminant

The colour of an object can change depending on the illuminant, e.g. tungsten light may cast a yellow colour compared to daylight.

The property of light source to influence colour of objects is called “colour rendition”. There are three main illuminants within any dental practice: natural, incandescent and fluorescent. Natural sunlight is itself variable with light appearing blue at noon when the sun has less atmosphere to penetrate, and red/orange during the morning and evening. Incandescent lighting is predominantly red/yellow and lacking in blue while fluorescent lighting is high in blue tones and low in red. There are special lights (Figure 2) that are colour corrected to emit light with a more uniform distribution of colour that can be utilised. Initial shade selection should be initially made with these lights then the shade should be matched under different lights to avoid metamerism (the phenomenon that occurs when shades appear to match under one lighting condition and not another).



Figure 1. Isaac Newton’s experiment of splitting light by a prism into the colours of the spectrum - red, orange, yellow, green, blue, indigo and violet.



Figure 2. Use of Optilume TrueShade - which consists of LED lighting to provide a colour corrected light output of 5500K.

## Object

Colour possess three dimensions: value, hue and chroma. A high value object often reflects most of the light falling on its surface and appears bright. The converse is true with a dark object absorbing most of the light and appearing dull or of low value. Hue is wavelength of light, and dependent on the spectral reflectance from an object. Chroma is the concentration of colour or colour intensity (Figure 3).

## Detector (sensation)

The third part of stimulus for colour is the spectral response of the detector, or eye.

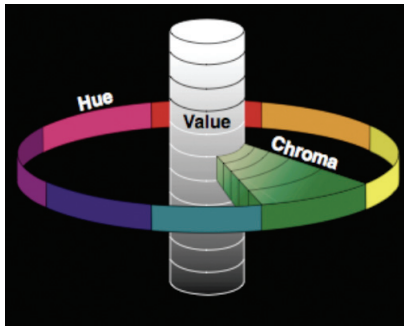


Figure 3. The Munsell color system, showing: a circle of hues, and levels of value and chroma.



Figure 5. Vita System 3D-Master shade guide.



Figure 4. Cross section of tooth demonstrating translucency of enamel that allows underlying dentine to show through.

The difficulty of shade selection is that clinicians must be able to interpret a multi-layered structure of varying thickness, opacities and optical surface characteristics. This can affect the way that the eye perceives colour.

The basic hue of the tooth is determined by the colour of the underlying dentine, while value is a quality of the enamel overlay. Muia in 1993 stated, "The dentine imparts all the colour. Enamel is like a fiberoptic structure conducting light through its rods". Chroma is the saturation of colour in the dentine, but is influenced by the value and thickness of the enamel. Teeth are often termed "polychromatic" and have the variation in hue, value and chroma within the teeth and give three dimensional depth and characteristics (Figure 4).

A young dentition is characterised by opaque, high value enamel, which blocks underlying dentine. As teeth age, the enamel becomes more translucent and dull (low value) revealing the underlying dentine. This layering can make reading of tooth colour difficult since the value of enamel and surface lustre often complicate colour evaluation of the underlying dentine.

### Types of shade guides

The most popular shade guides are:

- Vita Classic
- Vita System 3D-Master
- Chromascop
- Custom or specific chroma and value guides

The author's choice of shade guide is the Vita System 3D-Master (Figure 5) with the aim of accurately assessing shade according to the three components of colour: hue, value, chroma. Shade tabs are arranged systematically and logically, rather than randomly in the Classic shade guide (see Table 1).

It consists of 11 fired porcelain tooth shaped samples built up with cervical, dentinal and incisal powders and composed of feldspar nepheline and high temperature ceramic pigments. The 11 sets consist of 26 samples ranging from lightest to darkest value, from lowest to highest intensity and from yellow to red.

Vita Value, Chroma and Hue correspond similarly to Munsell value, hue and chroma representing the three dimensions of colour. The tabs are grouped into 5 categories, sequentially numbered with increasing value (1-5). All tabs within the value group have the same brightness. In each of the groups the chroma increases from top to bottom. All the groups except 1 and 5 have 3 letters: L, M, R, which allows the hue to be chosen. L (light) is yellow, M (medium) is yellow-red, and R is a red hue.

Documenting of this shade is with a number/letter/number system. The first number indicates the value group (1-5), letter is the hue (L, M, R) and the chroma (1-3). E.g. 3M2 is the 3rd value group, M hue sub-group, and 2 chroma level.

Table 1.

Chart for approximating Vita Classic shades using Vita System 3D-Master shaded VM13 porcelain

Shade	Opaque	Enamel	Base Dentine Ratios
A1	OP1	ENL	1M1 : 1M2 (1:2)
A2	OP2	ENL	2M2 : 2L1.5 (2:1)
A3	OP3	ENL	3M3 : 3L1.5 (1:1)
A3.5	OP3	ENL	3R2.5 : 3L1.5 : (1:1) Add 10% EC3
A4	OP4	ENL	4L1.5 : 4M2 (2:1)
B1	OP1	ENL	1M1
B2	OP2	ENL	2L2.5 : EC3 (1:1)
B3	OP3	ENL	3L2.5 : EC4 (1:1)
B4	OP3	ENL	3L2.5 : EC5 (2:1)
C1	OP3	Extra ENL	3M1 : 2L1.5 : EC11 (1:1:1)
C2	OP3	ENL	3L1.5 : EC10 : EC11 (2:1:1)
C3	OP4	END	4L1.5 : EC11 (1:2)
C4	OP5	END	5M1 : EC10 : EC9 (1:1:1)
D2	OP3	Extra ENL	3M2 : 2L1.5 (2:1)
D3	OP3	ENL	3M1 : 4L1.5 (1:1)
D4	OP3	ENL	3L1.5 : EC11 : EC4 (2:1:1)

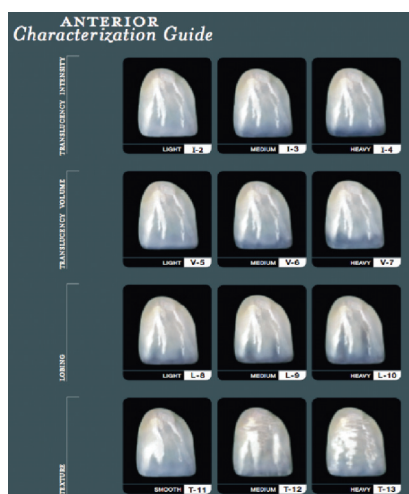


Figure 6. Characterisation guide (Macveneers: Microdental Laboratories, CA, USA).

The shades of the lightness level 3 cover 50% of the natural tooth shades. The shades of the lightness levels 2 and 4 cover an additional 46%.

VITA has also created a bleached tab, labeled the “0” (zero) group, to allow dentists to create bleached restoration shades.

One of the other advantages of the Vita System 3D-Master is the repeatability of shade selections with the system. It was concluded that use of this system compared to the classic guide improved intrarater repeatability among general practitioners (Hammad I, 2003).

A number of related factors in selecting shades must also be understood to achieve a successful result. These factors include, translucency, contour, surface texture, and lustre (Winter R. 1990). Selecting the basic shade or colour is only the first step.

### Translucency

There are various patterns of translucency and this may also affect value as increasing translucency decreases value. The amount, location and quality of translucency varies with individual and age. Young teeth often have greater incisal translucency with the enamel often appearing transparent. With age, from daily functions like eating and brushing, the enamel becomes thinner and allows the underlying dentine to appear. This is seen with the teeth becoming lower in value and higher in chroma (Figure 6).

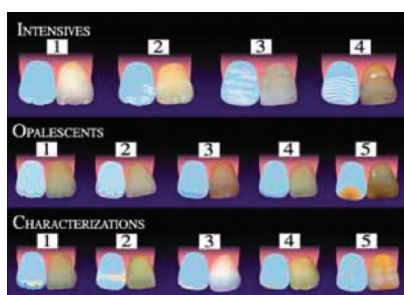


Figure 7. Vanini's classification of enamel effects. Three categories: intensive, opalescent and characterisation. Understanding this categorisation will provide the clinician a simple road map to colour matching. By memorising three categories with a total of fourteen subdivisions, the clinician has a definite route to chart the shade selection process, without the need for exceptional artistic ability (Vanini L and Magani FM, 2001).

Vanini (2001) has suggested that there is a definite pattern to the translucencies (Figure 7). He postulates that the sum total of all opalescent, translucent or enamel effects fall into one of three categories:

1. Intensive effects;
2. Opalescent effects; and/or
3. Characterisation.

### Surface texture

Surface texture influences aesthetics by determining the amount and direction of light reflected off the facial surface. Texture should be designed to simulate the reflectance pattern of the adjacent natural teeth. Young teeth may have a lot of characterisation with stippling, ridges, striations and lobes. These features may be worn away with age leaving smoother, highly polished surfaces (Figure 8).

### Shade selection sequence

- Shade selection should be completed before preparation as teeth can become dehydrated and result in higher values.
- Shades should be done when the dental team is not fatigued as in the end of the day.
- Ensure surgery surroundings are of neutral colour so that there is no colour cast onto the teeth.
- Remove lipstick; ask patients not to wear lurid clothing or any items that may distract the attention of the teeth.
- Make sure teeth are clean and unstained before attempting shade selection.

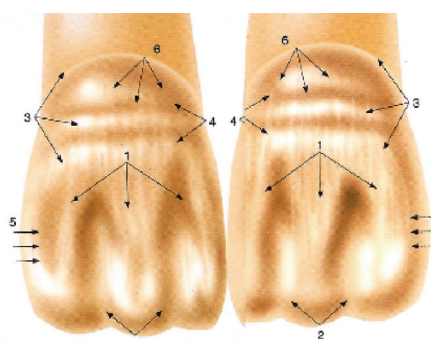


Figure 8. Surface texture of teeth - 1. Vertical ridges; 2. Vertical grooves; 3. Horizontal ridges; 4. Horizontal grooves; 5. Perichymata; 6. Enamel pits and irregularities (Sulikowski and Yoshida. Surface Texture: A systematic approach for accurate and effective communication. Quintessence Dent Tech 2003;26:10-20).

- Patient should be in an upright position at a level similar to the operator and the shade guide should be at arms length. This ensures that the most colour sensitive part of the retina will be used.
- Observations should be made quickly (5 seconds) to avoid fatiguing the cones of the eyes. If longer than this, the eye cannot discriminate and the cones become sensitised to complement the observed colour.
- Blue fatigue can accentuate yellow sensitivity so dentists can look at a blue object, bib, etc, while resting the eyes.
- Use colour corrected light illumination, which should be of a diffuse nature.
- Choose basic shade at the middle of the tooth - using the Vita System 3D-Master technique of value, chroma then hue. Use blue card to avoid chromatic adaptation. Viewing tabs through half-closed eyes can decrease ability to discriminate colour but increases the ability to match value. Look at the other parts of the teeth, dividing the teeth into 9 sections from apical to incisal, and mesial to distal.
- Necks of shade tabs often can be removed as they have a great deal of colourants that may introduce errors.
- Examine tooth for translucency and any characterisations, e.g. craze line, hypocalcification, etc.
- Create a shade/chromatic map - divided into different sections to ensure correct placement of different effects, characterisations and shades.



Figure 9. Dark stump shades of prepared endodontically treated teeth.

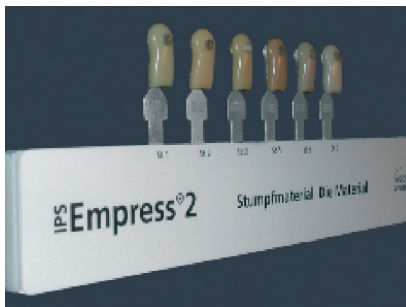


Figure 10. Empress Stump Shade Guide (Ivoclar Vivadent).

- Photograph teeth and tabs using different lighting conditions to minimise metamerism, e.g. flash (5500K) and natural daylight (6500K).
- Photograph teeth at a 1:1 ratio for detailed characterisations.
- Send digitised images and shade map to ceramist.

### Stump shade selection

With the increasing use of all-ceramic restorations, it is important to communicate the prepared tooth or “stump” shade (Figure 9) to the ceramist so that they can build the restoration with the right opacity/translucency. It may be necessary as in Figure 10 to use a more opaque ceramic to block out discolouration, e.g. an alumina- or zirconia-based restoration may be a better choice than a glass-based ceramic like Empress.

### Instrumental assessment

In selecting shades, often the author has also used different devices to assist in selection of shades, e.g. ShadeVision, Shade Pilot, Vita Easyshade (Figures 11-13). This may eliminate clinician subjectivity.

There are 3 basic types of devices used:

1. Spectrophotometry e.g. Vita EasyShade.
2. Colourimeter e.g. ShadeVision.
3. Digital camera and RGB devices e.g. ShadeScan.

### Conclusions

Correct shade selection is essential in the provision of aesthetic restorations. Understanding the influence of different variables in shade selection from light illumination to the tooth's hue, value and chroma and how the eye interprets this can assist in this selection.

The use of the Vita System 3D-Master that allows a logical selection of colour into hue, value and chroma. There are limitations of shade guides as they fail to account for the variability found in natural teeth, e.g. fluorescence, opalescence, translucency, enamel thickness, and objectivity. Vanini has classified the translucent effects in an attempt to allow better communication of these effects. Effects of surface texture on light reflection and different characterisations must be recorded and duplicated in the final restorations. The use of technology with different devices in shade selection may eliminate subjectivity of choosing and the use of photography to communicate shades and characterisations has improved the selection process.

A procedure of shade selection has been described to ensure consistent results considering the different variables that influence shade matching. Good communication between the dental team of all these details is paramount to a successful aesthetic result.

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### About the author

Dr Christopher Ho received his Bachelor in Dental Surgery with First Class Honours from the University of Sydney in 1994 and completed a Graduate Diploma in Clinical Dentistry in oral implants in 2001. He is a Clinical Associate with the Faculty of Dentistry at Sydney University.



Figure 11. The ShadePilot tooth shade analyzer from DeguDent (Dentsply) features a digital camera linked to a LED spectrophotometer.



Figure 12. The VITA Easyshade (Henry Schein) integrates a powerful spectrophotometer into a small and compact unit for determining the shades of teeth.



Figure 13. The X-Rite ShadeVision (Henry Schein) incorporates a colourimeter and integrated light source.

In addition to teaching at undergraduate level, he has lectured and given continuing education presentations in Australia and overseas on a wide range of topics related to cosmetic and implant dentistry. He maintains a successful private practice centered on comprehensive aesthetic and implant dentistry in Sydney, Australia.