FACTORS AFFECTING COLOR

Nikoleta Stoykova, Svetozar Yankov, Svetoslav Slavov, Petya Kasnakova
Medical College at Medical University, Plovdiv
Plovdiv, 120 "Br. Buxton"4000

ABSTRACT

Dental technicians and dentist have been dealing with the effect of colors in prosthetic structures for a long time. The main purpose is to produce restorations, identical with the natural specimen. In order to improve the result we explore indepth the natural phenomenon, the appearance and the laws related to them. The industry offers new materials, which give us the opportunity to re-create the natural shade of dental structures. Enriching our knowledge of the shape and color, we aspire to optimize the effect of lamination techniques with the respective materials, which influence one determinant: light.

Key words: *light, natural shade, dental structures*

Introduction: According to modern science, the light that is visible to the human eye constitutes a tiny part of the vast spectrum of electromagnetic waves, and is in the range of 380-750nm. The human eye can perceive and distinguish between the oscillations of light within this range only. The wave of the colour violet is the shortest (400nm), followed by that of blue (450nm), of the green (500nm), of the yellow (570nm), of the orange (590nm) and the wave of the colour red is the longest (610nm). Ultraviolet radiation (under 400nm), as well as the infrared one (над 700nm) are imperceivable to us. The human eye is unable to select this mixed light, and because of this fact, the human eye does not perceive it as monochrome colours of the different wave lengths. The visible light is polychromatic, that is, it is comprised of different colours. Mixed light is selected by three phenomena:

- **Reflected colour** – a red object reflects the red part of light and absorbs the other colours.
- **Penetrating colour** – a transparent object reflects a part of the light and absorbs the other.
- **A selection of mixed colours –** interferences, such as diffraction and refraction of light [4].

The sun is the main and most important source of visible and invisible light. The intensity and composition of daylight fluctuate throughout the day, and depend mainly on the position of the sun and the atmospheric conditions. The air molecules and the particles of dust diffract the blue and ultraviolet ray the most, as their wavelength is the shortest and closest to the size of the air molecules. This phenomenon determines the blue colour of the sky during the day. In the morning and at dusk, when the sun approaches the horizon, the diffraction and absorption of short-length waves are the greatest, and as a result of this, the yellow, orange and red rays predominate in the visible light. The changes in the quality and quantity composition of daylight cause the appearance of certain optic phenomena – metamerism, opalescence, etc. [2]. This calls for them to be studied in detail by dental specialists, whose professional competences concerning colour require that they should be able to:

1. determine colour
2. communicate colour
3. reproduce colour
4. control colour [5].

Discussion:

„Colour is not a property of the object but rather of the light reflected by the object."
J. Preston, L.Ward, M.Bobrick, 1978

The colour of an object is determined by the spectral composition and intensity of the light that falls on it; the changes that the light undergoes in its contact with the object (refraction, reflection and absorption), and hence by the composition of the light reflected by it. Therefore, the composition of the reflected light depends on the light source (artificial, natural light) and on the value of the processes of absorption and reflection, dependent on the nature of the specific object [2].

The light coming from the object reaches the human eye, there it is focused by the lens onto the retina, and causes certain nerve impulses which go to the brain [2]. From an anatomical ppoint of view, the most accurate colour perception by the human eye is achieved when the pupil is open wide enough for the cones in the fovea centralis (which takes up over 50% of the visual cortex in the brain) to be fully exposed. This is achieved when the brightness of the light is adequate. Colour, like shape, has three dimensions and is characterized by three values – hue, chroma and value.

E. Clarke, 74 session of ADA, 1932 [2].

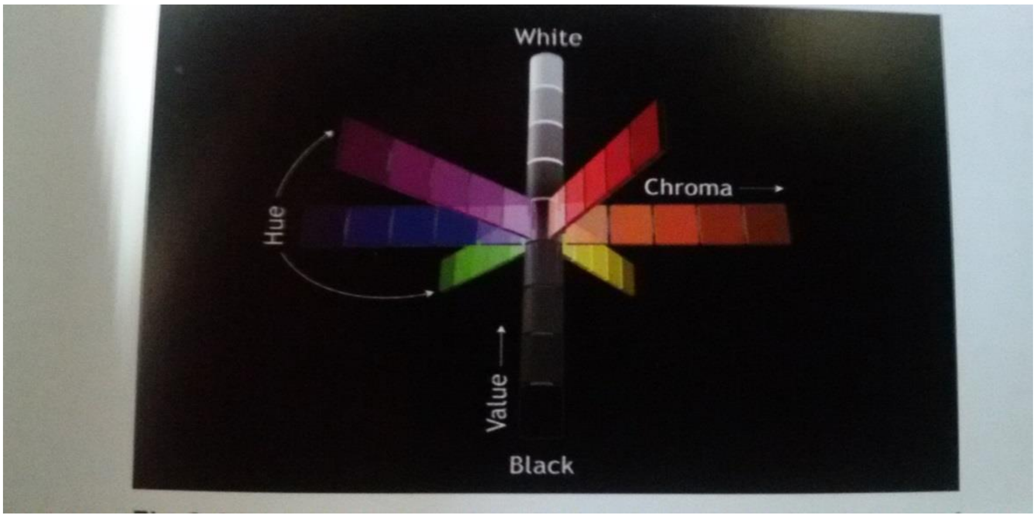

Fig. 1 The wheel of colour- Munsell [7]

Hue (name of the colour)

The first dimension is that of hue, and it determines its place in the colour range [2]. This allows us to distinguish between one family of colours and another. For instance, red and green constitute two different colour families. In the Munsell system of colours, the various colour hues form the periphery of the colour wheel – Fig. 1 [3].

Chroma (colour purity or saturation)

The second dimension determines the quantity of the colour in a certain object. In the colour space, chroma is determined by the length of the vector from the centre to the periphery of the colour wheel. In practice, it is assumed that one and the same colour can be defined as strong (intense, vivid) or weak. The more saturated a colour, the higher its chromaticity [2].

Value (the lightness, vitality or brightness of the colour)

The third dimension determines the quantity of white, grey or black in a certain colour. The value is of great importance in determining the colour of teeth. Teeth with a predominant white colour look light and vital. On the contrary, teeth with a low value of the colour look dark. In other words, value of the colour can be used to describe the colour of teeth from the point of view of lightness or shine [2]. The lightness (brightness) of the colour is the most important of the three colour dimensions. The human eye is unable to perceive the subtle differences in hue and chroma, yet differences in value are easily perceived [3]. On the colour wheel, value serves as an axis. There are also the so called contrast effects – these are visual phenomena which may affect our perception of colour, as well as our ability to determine colour objectively. These effects create optic illusions which are difficult to identify by an unprepared observer [7].

❖ **Double contrast**- when two colours are observed at the same time, the brain tries to reach a harmonious balance. In this case, our perception is influenced by three factors:

1. **Whitening contrast** (surrounding light) – if the surrounding light is dark, the object looks lighter, and vice versa [7].
2. **Hue /nuance/ contrast** (surrounding colour) – when a colour is observed simultaneously with another one, the perceived nuance of the first colour will look closer to and complementing the second colour. Dental professionals can prepare for determining a colour by looking at a complementing colour prior to that; since teeth colours are usually in the orange family, it is recommended that the dental professional should look at something light blue [7].
3. **Contrast saturation** (surrounding relative saturation) – an object willl look much more saturated against an unsaturated background, and vice versa [7].

It is considered that the grey colour is soft to the eye, and as a background colour does not cause any sensory strain. Thus the significant 'messages' can come to the foreground. The advantage of the pure grey colour (without refraction of the colour) is that all colour receptors in the human eye and brain are activated with the same intensity [6].

❖ **Metamerism**- metamerism is the change in the colour correspondence between two objects when they are exposed to different light sources [1]. This change can be explained with the occurrence of some optical phenomena – fluorescence, opalescence, etc., which are contingent upon the quantity and quality composition of the light in which the colour of teeth is determined.

When two objects are of the same colour, exposed to one light source, and of different colours when exposed to another light source, they are defined as a metametric couple. The isometric couple is the opposite of the metametric one; these are objects whose colour is the same when exposed to different light sources. Metamerism is a common phenomena in clinical and laboratory practices. The different light sources, such as furniture, flooring, wall colour, in a dentist's surgery and the dental laboratory, may create the impression of a 'sham' colour correspondence, which can be detected after the ceramic structure is completed [2].

The only way to avoid metamerism is to achieve a match in the spectral arc, pairs of coloured objects which have equal spectral arcs will always coincide, regardless of the light in which they are observed [7].

Although some companies, manufacturers of dental products, try to cope with metamerism by developing materials which can demonstrate the chameleon effecr, adopting the colour of the ambient environment, metamerism is still a problem in the dental laboratory. In order to deal with it, the clinical practitioner may determine the colour in several types of light. Yet, it is possible for a certain degree of non-correspondence between the estjetic restoration and the natural teeth. The patient has to be informed that this is not a mistake but a normal phenomenon due to the different components of the reconstruction materials [7].

Opalescence (opal effect) results in certain exposition to light and refraction of the light on microcrystal components of various sizes. Tooth enamel acquires a bluish colour when it reflects light, and when light passes through it – it looks orange. In this way, the enamel imitates the reaction of the opal, the semi-precious stone, and hence the name of this effect. Natural tooth enamel consists of calcified rods, made up of numerous hydroxylapatite crystals and water. It is them that teeth opalescence is due to. Because of their prism structure, the light that falls onto them disintegrates into the colours of the spectrum. As the refraction rate of these particles is different, the falling light diffracts, and as a result, the enamel looks orange-pink in colour. The opal effect is due to the tooth enamel, Fig.2, Fig.3 [4].

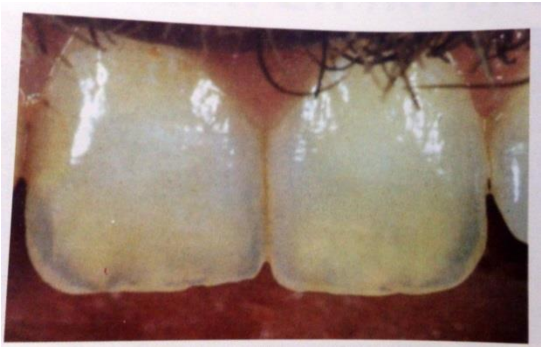

Fig. 2 *Fig. 3*

Fig. 2 Light that falls directly produces a grey-blue effect.
Fig. 3 Reflected light causes a red-orange opal effect [4].



Fig. 4
Fig.5 *Fig. 6*

Fig.4 Under reflected light, the long-wave components stand out.

Fig. 5 Under directly falling light on one side, where the light falls, the tooth surface looks blue-white.

Fig. 6 In diffracted light from both sides, the whole surface looks bluish-white [4].

Fluorescence. This term describes the absorption of light rays of certain wave-lengths, and their reflection with the same or longer wave-length. For example:

If directed ultraviolet light passes through natural or artificial teeth, it is an indicater of the increase of their fluorescence. In the composition of natural teeth, there are organic substances (proteins) and inorganic compounds (fluorapatite crystals), which have a fluorescent effect. Dentine (the dentine nucleus) is a determining factor for the optic properties of the tooth. Fluorescence contributes to the optimal distribution of the light flux and the reflections it causes, Fig.7 [4].

Fig.7 *Fluorescence.*

When certain substances are illuminated, they start giving off light themselves. Dentals ceramics are coloured by bluish-whitish fluorescences, and then emit a blue-white colour. This phenomenon occurs especially in infrared light, diffused light (bow) and sunlight [5].

Light permeability: transparency and translusency.

The effect of colour occurs from the reflection of light. Light is reflected not only by the surface, but also in-depth, due to the translucency of natural teeth, that is, translucent areas in natural teeth are, at the same time, subjected to the strong influence of the environment. In different light conditions, the impression of colour may vary considerably [5].

Translucency is determined as the quality which permits light to permiate, but only diffusely, so that the object on the other side cannot be clearly distinguished; not enough to be transparent. A translucent object causes sufficient deffraction /diffusion/ of light so that only a blurred /dim/ image of what is behind it can be seen.

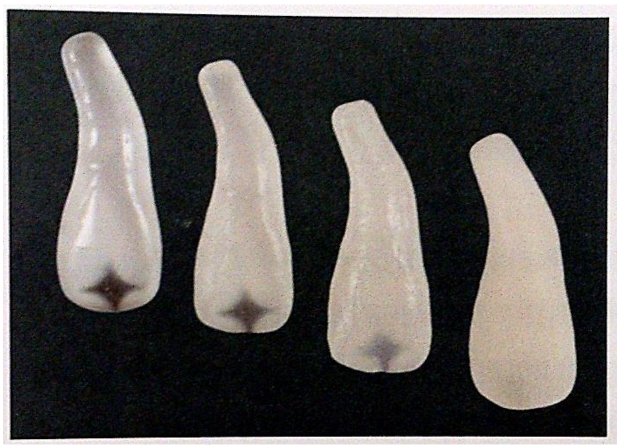

Fig.8

Fig. 9

The more translucent an object is, the deeper light penetrates in it, and the greyer it looks. The more opaque it is, the more the grey decreases and the whiteness increases. Fig.8, Fig.9 [5].

Conclusion:

Choice of reconstruction materials

The choice of reconstruction materials is of vital importance in achieving the right nuance. The material should have similar optic properties (opalescence, fluorescence, translucency) to those of natural teeth.

Some materials possess a high degree of translucency (such as synthetic ceramics), whereas others have a high degree of opalescence (for example zirconium), and that is why it is really important to establish the colour properties of the material.

Porcelain includes in its composition agents thanks to which prosthetic reconstructions may look fluorescent, which gives them a natural appearance.

Materials also have to combine in themselves good medical-biological qualities, physical and chemical properties (chemical composition, granulometry), and highly esthetic properties, too. It is also important that they should be easy to work with – they should be easy to process in laboratory conditions. Thanks to them, the dental technician will be able to reproduce the right colour, and to have control of the colour through minimum corrections and pigment colourings. The use of materials which meet these criteria will yield the desired results – ceramic structures with excellent physical and optical properties and appearance.

Sources of Reference

1. Kisov, Hr. Ceramic facets. Clinical and laboratory protocol. Publisher: ‘Continuous improvement’ EOOD, Sofia 2008 : 170

2. Kisov, Hr. Dental ceramics. Part 1: Basic principles, materials and tools. Sofia 1997 : 27-35;58-59

3. Nailer, P. Fundamentals of metal-ceramic technology. Publisher: ‘Medior’ Varna, 1996 : 154-155

4. Koler, V., Lansberg. Origin and effect of light: observations on tooth structure. ‘Dental technique’, No. 5 - 6 IX- XII, Publisher:. „Eratos“ Ltd., Sofia, 1995 :10-12 ; 23

5. VITA VMK MASTER, Vita Impressum, Postfach, Germany, Ръководство за работа. 2009 : 7

6. VITA INFO, Vita Impressum, Postfach, Germany, 2009 : 16

7. Stephen J. Chu, Alessandro Devigus, Rade D.Pararina, Adam J. Mieleszko. Fundamentals of Color – Shade Matching and communication in Esthetic Dentistry- second edition. Qiuntessense Publishing Co. Inc. 2010 : 24-26 ; 27-33