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Research Article

Effect of Illuminants, Colour Cards and Shade Guides on Shade Matching - A Comparative Study

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Abstract

Introduction: The present study was conducted to find out the effect of different light sources viz., sunlight, incandescent light, halogen light, tube light and colour corrected light on shade selection. The effect of gazing at blue and grey cards and usage of Vitapan Classic and Vitapan 3D master shade guides.

Materials and Methods: Two shade tabs were selected from Vitapan Classic and Vitapan 3D Master (Vita Zahnfabrik, Germany) shade guides. Matching to the selected tabs, a feldspathic and a pressable ceramic disc was fabricated. Shade selection was done under five different light sources. The shade matching procedure was repeated after a few days by the volunteers after gazing at a blue coloured card for ten seconds and again after a few days after gazing at a neutral grey coloured card for ten seconds. The shades selected were recorded in a proforma. The entire shade matching procedure was repeated again for a second time.

Results: The light source was found to be a significant factor in influencing the correct identification of shade ($P<0.001$). Use of coloured cards improved the shade matching when compared to the non-usage of cards ($P<0.001$). The Vitapan 3D Master has higher odds/chances of correctly identifying the right shade, when compared to Vitapan Classical shade guide ($P<0.05$).

Conclusions:

- Sunlight is superior to other light sources. But when artificial lights have to be used, a color corrected light or the light from the dental chair (halogen light) can be used to obtain better shade matches.
- Gazing at neutral grey and blue card is an effective adjunct in improving the quality of shade selection.
- The Vitapan 3D Master shade guide was a better shade matching tool than Vitapan Classical shade guide.

Keywords: Shade Matching; Illuminants; Shade Guides; Vitapan Classic; Vitapan 3d Master; Colour Corrected Light; Blue Coloured Card; Neutral Grey Coloured Card

Introduction

Colour is the result of physical modification of light by the colorants and it is observed by the human eye and interpreted by the brain [1]. Colour is probably one of the most important determinants of aesthetics in restorative dentistry. Colour science related to clinical dentistry primarily centres around choosing the accurate shade of a tooth, selecting the most appropriate material and communicating precisely with the technicians to achieve good aesthetic results [2]. Shade selection was primarily evolved as a human process but later technological advancements have improved this and approximated it towards perfection. However, shade selection against the oral environment making use of human vision remains as an unavoidable clinical method because of its relevance.

It is estimated that about one million shades can be distinguished by the human brain and the perception of colour depends on the environment in which the object is presented [3]. However, the traditional method of shade selection is associated with inconsistencies and a host of variables such as degree of colour - vision deficiency of the operator, standardization of the shade guides and type of lighting used for shade matching [4]. Light source tops the list of variables that control the process of shade selection. The natural light occurring between 12 noon and 3 PM in the northern hemisphere with slight overcast conditions is considered as an ideal situation for accurate shade matching [5]. The standard daylight is not always available because of the changes in weather and other physical restrictions. In that context, operators have the only option of using artificial light sources for shade matching purposes. Prolonged duration of shade matching will result in fatigue of the eyes, for which the literature has suggested that the operator should gaze at a blue or a neutral grey coloured card and thereby preventing the effect of fatigue and to some extent avoiding the after image formation [6]. The present study aims to compare the effect of illuminating sources viz., sunlight, incandescent light, fluorescent light, halogen light and a colour corrected light on shade selection; and also, to find out the influence of shade guides and coloured cards on shade determination. The following were the objectives of the study

- To determine and compare the shade of ceramic specimens under five different light sources viz., sunlight, incandescent light, halogen light, tube light and colour corrected light.
- To find out the effect of gazing at neutral grey and blue coloured cards on shade determination.
- To find out the comparative accuracy of two shade guides viz. Vitapan Classic and Vitapan 3D master in obtaining a shade match.

Methodology

The present study was conducted to determine and compare the shade of ceramic specimens under sunlight, incandescent light, fluorescent light, halogen light and colour corrected light (Figure 1).

Room for shade matching

Shade matching was conducted in a room where external light was controlled by dark drapes (Figure 2). The room had provisions to connect tube light, incandescent bulb and halogen bulb.

Light sources

Shade selection was done under five different light sources viz., sunlight, incandescent bulb (40W, Philips, India), fluorescent tube (36W, Philips Lifemax, India), halogen bulb (12v, 55W, Mico Bosch, India) and a hand-held colour corrected lamp (5500°K, True Light, GDP Dental Products, India) (Figure 3-7).

Preparation of specimens

Two groups of specimens were used for the present study. Each group consisted of six specimens of which two were shade tabs selected one each from Vitapan Classic and Vitapan 3D Master (Vita Zahnfabrik, Germany) shade guides. The other four specimens were fabricated discs of feldspathic (Duracem Plus, Germany) and pressable ceramics (Ivoclar IPS e.max Ceram, Liechtenstein). The discs were color matched to the selected shade tabs. Similarly, one more group of specimens were made (Figure 8,9). The shades of the fired ceramic specimens were re-evaluated using a spectrophotometer (Vita Easyshade Advance). The distribution of the specimens is given in Table1.

Procedure for shade matching

The volunteers belonged to the teaching staff, post graduate students and interns and they were screened for colour-blindness using Ishihara's tests for colour blindness (Kanehara and Co., Ltd, Japan). Colour blind volunteers were excluded from the study.

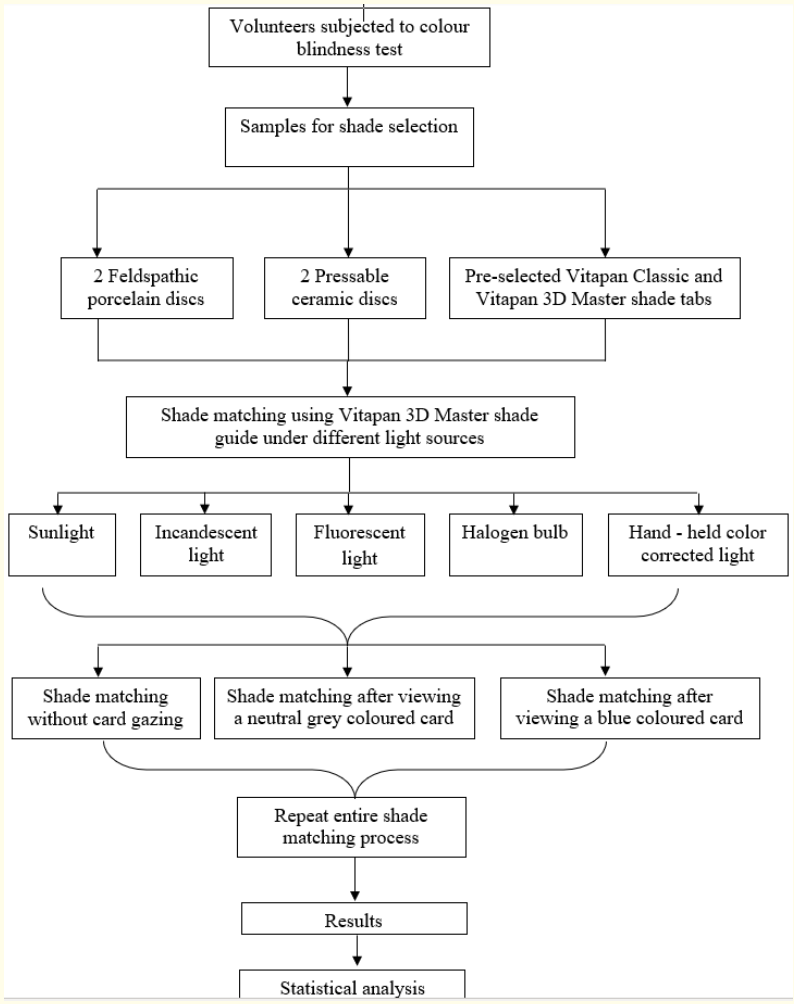

Figure 1: Flowchart on methodology.

Figure 2: Room in which experiment was conducted.

Figure 3: Shade matching under sun light.

Figure 4: Incandescent lamp.

Figure 5: Flourescent lamp.

Figure 6: Halogen lamp.

Figure 7: Handheld colour corrected light.

Figure 8: Shade matching specimens of Group I.

Figure 9: Shade matching specimens of Group II.

Each volunteer had to evaluate the shade of 12 specimens as described in Table I. The specimens were placed on a black coloured platform mounted on a tripod (Figure 10). They were shown to the volunteers randomly using a random number generator. Each volunteer was given a proforma to enter his/her shade selection. For each light source, the volunteer was provided with a new proforma to note down the shade selection to avoid bias from the previous shade selection. For the shade selection under sunlight, the volunteers were asked to sit near an open space with the sunlight falling from behind (Figure 3). The shade selections under the remaining light sources were done in the shade selection room. Each volunteer was given a time of 10 seconds for the shade selection after which the light source was switched off. Five days after the shade matching under the five light sources the volunteers were again asked to determine the shade of the specimens after gazing at a blue coloured card for ten seconds (Figure 11). Again, after five days the volunteers were asked to determine the shade of the specimens after gazing at a neutral grey coloured card for ten seconds (Figure 12). The shades selected were recorded in the proforma.

Procedure for shade matching with the 3D Master shade guide (Figure 13)

The shade guide was held at an arm's distance by the vulunteer. Only the top row of shade tabs i.e., 1, 2, 3, 4 and 5 were compared while selecting the appropriate lightness value starting from the darkest to the lightest. The objective at this stage was to determine the correct lightness value and not the actual shade of the specimen. On the basis of the value (1 - 5) determined, the middle set (M) of the selected value group was taken for determining the chroma. After fanning them out, one of the shade samples was selected. To determine the hue, the specimen's colour was checked to see if it had a more reddish hue (R) or more yellowish hue (L) than the sample selected.

Procedure for shade matching with the Vitapan Classic shade guide (Figure 14)

The hue group (A - D) closest to that of the specimen was selected first. After the hue selection was made, the chroma was selected from the gradations within the selected hue tabs (A1 - A4). The value was determined by squinting with comparisons made at arm's distance and the specimen fading first had a lower value. Following value selection, tabs selected for hue and chroma may not coincide with shade tab selected for value. If the value of shade tab was less than the specimens, then a new shade tab was selected which had a higher value. If the value of the shade tab was more than the specimens, a new shade tab was selected which has a lower value.

Results and statistical analysis

The results were tabulated and subjected to Logistic Regression/ Log Linear analysis and Chi-squared test to detect statistically significant differences.

Figure 10: Display of specimens used in the experiment.

Figure 11: Blue coloured card.

Figure 12: Neutral gray card.

Figure 13: Vitapan 3D Master shade guide.

Figure 14: Vitapan Classic shade guide.

Group	Specimen No.	Description
I	1	A2 of Vitapan Classic shade guide
	2	C2 of Vitapan Classic shade guide
	3	Disc of feldspathic porcelain matching to A2
	4	Disc of pressable ceramic matching to A2
	5	Disc of feldspathic porcelain matching to C2
	6	Disc of pressable ceramic matching to C2
II	7	2M2 of Vitapan 3D Master shade guide
	8	4L1.5 of Vitapan 3D Master shade guide
	9	Disc of feldspathic porcelain matching to 2M2
	10	Disc of pressable ceramic matching to 2M2
	11	Disc of feldspathic porcelain matching to 4L1.5
	12	Disc of pressable ceramic matching to 4L1.5

Table 1: Description of the specimens used in the study.

Results

The percentage of correctness in identifying the shade of specimens obtained from all the volunteers with and without the use of colour card gazing prior to shade determination under different light sources is given in Table 2-4. The values obtained with Vitapan Classic and Vitapan 3D Master shade guides incorporating the light source variables and colour cards are given in Table 5-8. The values of logistic regression and log linear analysis are given in Table 9.

Specimens no	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
1	25%	25%	50%	50%	75%
2	25%	25%	33.3%	41.6%	58.3%
3	25%	8.3%	25%	25%	66.6%
4	41.6%	33.3%	33.3%	41.6%	50%
5	16.6%	16.6%	50%	58.3%	58.3%
6	58.3%	25%	41.6%	50%	83.3%
7	66.6%	25%	75%	75%	83.3%
8	58.3%	25%	58.3%	58.3%	66.6%
9	25%	33.3%	33.3%	25%	66.6%
10	25%	16.6%	50%	58.3%	50%
11	25%	16.6%	50%	58.3%	75%
12	41.6%	33.3%	58.3%	50%	50%

Table 2: Percentage of correct shade determination made by all the volunteers under different light sources.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
1	50%	8.3%	25%	75%	83.3%
2	50%	33.3%	33.3%	58.3%	83.33%
3	50%	33.3%	25%	58.3%	58.3%
4	58.3%	50%	50%	58.3%	66.6%
5	50%	25%	41.6%	41.6%	66.6%
6	50%	8.3%	25%	50%	66.6%
7	75%	25%	58.3%	25%	75%
8	41.6%	33.3%	16.6%	75%	75%
9	41.6%	25%	50%	66.6%	66.6%
10	50%	33.3%	25%	41.6%	66.6%
11	41.6%	33.3%	33.3%	33.3%	50%
12	25%	8.3%	50%	41.6%	66.6%

Table 3: Percentage of correct shade determination made by all the volunteers under different light sources after gazing at a blue card.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
1	58.3%	25%	33.3%	66.6%	83.3%
2	50%	25%	50%	75%	75%
3	66.6%	33.3%	50%	75%	83.3%
4	66.6%	41.6%	41.6%	58.3%	58.3%
5	41.6%	41.6%	50%	66.6%	83.3%
6	58.3%	41.6%	50%	58.3%	66.6%
7	41.6%	33.3%	33.3%	75%	83.3%
8	83.3%	41.6%	58.3%	75%	83.3%
9	75%	50%	50%	83.3%	75%
10	41.6%	33.3%	50%	75%	83.3%
11	66.6%	33.3%	50%	66.6%	83.3%
12	58.3%	41.6%	50%	66.6%	83.3%

Table 4: Percentage of correct shade determination made by all the volunteers under different light sources after gazing at a grey card.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
1	41.6%	25%	25%	66.6%	83.3%
2	50%	25%	33.3%	66.6%	75%
3	41.6%	25%	25%	66.6%	75%
4	41.6%	33.3%	41.6%	50%	75%
5	58.3%	25%	33.3%	50%	75%
6	41.6%	25%	33.3%	58.3%	66.6%

Table 5: Percentage of correct shade determination made by all the volunteers under different light sources after gazing at a blue card using Vitapan Classical shade guide.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
7	66.6%	33.3%	41.6%	50%	83.3%
8	41.6%	33.3%	16.6%	75%	75%
9	58.3%	33.3%	41.6%	66.6%	75%
10	58.3%	25%	25%	66.6%	83.3%
11	58.3%	25%	33.3%	58.3%	66.6%
12	41.6%	25%	41.6%	58.3%	83.3%

Table 6: Percentage of correct shade determination made by all the volunteers under different light sources after gazing at a blue card using Vitapan 3D Master shade guide.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
1	75%	41.6%	41.6%	83.3%	91.6%
2	58.3%	33.3%	41.6%	66.6%	83.3%
3	58.3%	41.6%	41.6%	66.6%	75%
4	66.6%	41.6%	41.6%	58.3%	58.3%
5	50%	41.6%	41.6%	75%	75%
6	50%	41.6%	41.6%	66.6%	75%

Table 7: Percentage of correct shade determination made by all the volunteers under different light sources after gazing at a grey card using Vitapan Classical shade guide.

Specimens no.	Light sources				
	Sunlight	Incandescent light	Fluorescent light	Halogen light	Color corrected light
7	50%	41.6%	41.6%	66.6%	91.6%
8	66.6%	33.3%	50%	83.3%	91.6%
9	75%	33.3%	41.6%	83.3%	91.6%
10	50%	33.3%	41.6%	83.3%	91.6%
11	58.3%	33.3%	41.6%	75%	83.3%
12	75%	33.3%	41.6%	83.3%	91.6%

Table 8: Percentage of correct shade determinations by all the volunteers under different light sources after gazing at a grey card using Vitapan 3D Master shade guide.

Variables	β	SE of β	df	P-Value	Odds Ratio	95% CI for Odds Ratio	
						Lower	Upper
Shade Guide							
Viatpan 3D Master					1§		
Vitapan Classical	-0.17	0.06	1	0.010*	0.85	0.75	0.96
Light Source							
Colour corrected light					1§		
Fluorescent light	-1.00	0.10	1	<0.001*	0.37	0.30	0.45
Halogen light	0.38	0.10	1	<0.001*	1.47	1.21	1.78
Incandescent light	-0.38	0.10	1	<0.001*	0.68	0.56	0.83
Sunlight	0.85	0.10	1	<0.001*	2.35	1.92	2.86
Gazing at Colour Cards							
Blue card					1§		
Neutral grey card	-0.11	0.08	1	0.170	0.90	0.77	1.05
No card	-0.60	0.08	1	<0.001*	0.55	0.47	0.64

Table 9: Difference between various factors in correctly identifying the shade: (Logistic Regression/Log Linear analysis).

The different variables influencing the correct identification of shade guide considered in the present study are Shade guides, different light sources and gazing at colored cards.

§ Reference Category

*Denotes significant difference.

Light source was found to be a significant factor in influencing the correct identification of the shade (P < 0.001) of specimens. An odds ratio of >1 for halogen light (OR = 1.47) and sunlight (OR = 2.35) indicates that the odds/chances of identifying the right shade is more in sunlight followed by halogen light compared to color corrected light. An odds ratio of <1 for fluorescent (OR = 0.37) and incandescent (OR = 0.68) indicates that the odds/chances of identifying the right shade is less in these two light sources when compared to color corrected light (Table 9).

Shade guides were also found to be a significant factor in correctly identifying the shade (P < 0.05) of the specimens. Vitapan Classical shade guide, when compared to Vitapan 3D Master, has a lower odds/chance of correctly identifying the right shade (OR = 0.85).

Gazing at a colour card was found to be a significant factor in influencing the correct identification of the shade (P < 0.001) of specimens. An odds ratio of <1 for neutral grey card (OR = 0.90) and non usage of card (OR = 0.55) showed that the chances of identifying the right shade is less in these two categories when compared to blue card (Table 9). (OD - Odds Ratio).

Discussion

Success of dental restorations and replacement of teeth is dictated by a pleasing colour acceptable both to the patient and to the dentist and at the same time matching with the remaining teeth. Selection of the shade has been perceived as a specialized skill which is greatly influenced by the ambient light. Sunlight has been considered as an ideal light source but the practicality to bring it into the clinic has forced the operators to opt for artificial light sources like incandescent light, fluorescent light, halogen light and colour-corrected light. Shade matching with standard shade guides remains to be popular because of the easy availability and fairly good accuracy obtained, in spite of the advent of colorimeters and spectrophotometers. The present study was designed to integrate various influencing factors that act on the shade selection process such as illuminants, shade guides and supplementary aids like gazing at coloured cards.

- **Illuminants:** A light source that has a colour temperature of 5500^0 Kelvin is considered to be ideal by different research workers for shade matching in dental clinics. The colour temperature of sunlight is calculated to be 5900^0K and it has been found that some of the artificial sources are on par with or even superior to sunlight [7-12]. In the present study it was seen that light source was found to be a significant factor in influencing the correct identification of shade (P < 0.001). An odds ratio (OR) of >1 for halogen light (OR = 1.47) and sunlight (OR = 2.35) indicated that the odds/chances of identifying the right shade was more in sunlight followed by halogen compared to colour corrected light. An odds ratio of <1 for fluorescent (OR = 0.37) and incandescent lights (OR = 0.68) indicated that the odds/chances of identifying the right shade was less in these two light sources when compared to colour corrected light. In spite of the fact that obtaining the right quality of sunlight is difficult, it tops the list of light sources in providing good quality shade matching (Table 9).
- **Shade guides:** Vitapan Classic and Vitapan 3D Master shade guides were compared in the present study. Many authors have evaluated these shade guides and compared them for their accuracy and distinguishing capacity [5,7,8,13]. In general 3D master had an edge over the Vitapan Classic. In the present comparative evaluation, shade guide was found to be a significant factor in influencing the correct identification of shades (P < 0.05). Vitapan Classical shade guide, when compared to Vitapan 3D Master, had a lower odds/chance of correctly identifying the right shade (OR=0.85) (Table 9) as evidenced in other studies.
- **Gazing at Coloured cards:** The present study found that the use of coloured card was a significant factor in influencing the correct identification of the shade. Non-usage of card was significantly different from usage of either of the cards. The odds ratio of neutral grey card was 0.90 and for non-usage of card was 0.55. Blue card and neutral grey card had no significant differences in between. Many authors have recommended gazing at either grey or blue coloured cards to prevent fatigue of the eyes [5,7]. Paravina R D has done extensive studies on colour and shade guides expressed his option on grey coloured cards over blue coloured ones. The preference for grey has reason because it will not leave an after image whereas the blue colour can leave a yellow after image probably adding on to the tooth colour. An afterimage is an optical illusion that refers to an image continuing to appear after exposure to the original image has ceased. Prolonged viewing of a coloured patch induces an afterimage of the complementary colour (for example, yellow colour induces a bluish afterimage and vice versa) [14].

Conclusions

Sunlight is superior to other light sources. It is followed by the halogen light of the dental unit and the colour corrected hand held lamp. Fluorescent and incandescent lamps cannot give adequate shade matching accuracy.

Gazing at neutral grey and blue card is an effective adjunct in improving the quality of shade selection with grey card having a slight edge over the blue card. Avoiding this procedure can cause errors in shade matching.

The Vitapan 3D Master shade guide was found to be a better shade matching tool than Vitapan Classical shade guide.

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