The Effect of the Surrounding Light Sources on Shade Selection Accuracy

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Abstract

The purpose of this in vitro study was to assess the effect of different surrounding light sources on the accuracy of electronic shade selection.

Five different surrounding light sources were assessed the study: Daylight (Sunrise), Daylight (Sunset), Florescent, Room halogen and office halogen light. VITA classical Shade guide tabs have been chosen to be tested in this study with an electronic shade selection devise to identify the accuracy of shade selection. 10 readings of each shade tab matching were tested under each surrounding light environment. Data was statistically analyzed by calculating the average percentage of the accurate readings and one way ANOVA at 5% level of significance.

Statistical analysis of the data with one-way ANOVA revealed that, there was a statistically significant difference between the 5 light sources groups being tested in shade matching accuracy readings ($p \leq 0.05$). Sunrise light source demonstrated the highest shade selection accuracy percentages while Florescent light source demonstrated the lowest shade selection accuracy percentages. Only the A2 shade tab exhibited insignificant differences among the 5 light groups being tested.

The surrounding lighting conditions significantly affect clinical shade matching performance of dental professionals.

Natural sunrise daylight is considered the best light source in terms of shade matching accuracy.

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Introduction

Correct shade selection in restorative dentistry is an important esthetic goal of modern dental treatment, which largely affects patient satisfaction.[1] Tooth shade is most often assessed manually with a handheld shade guide tabs provided by different dental manufactureres.[2] However, the method is subjective, as color perception is affected by several parameters, e.g., shade, saturation, brightness, translucency, opalescence, reflectance, and fluorescence,[3] as well as by the individual differences of the human eye and brain.[4] Color perceived by the human eye may be distorted by lighting conditions, gingiva color and the colors of the surrounding environment.[5] In order to improve the esthetic outcome of the treatment and choose the best tooth shade for the patient, a growing number of devices have been made available to assist dentists in optimizing the process of color evaluation and shade selection. Such aids for qualitative and quantitative color evaluation include digital cameras, colorimeters and spectrophotometers.[6,7]Other noteworthy products include lamps specially designed for color matching. Factors affecting artificial tooth shade matching include the source of light, the object observed and the observer.[4] Three sources of light are available in a dental surgery: natural daylight, which is highly variable; the operating light of a dental unit, with a bias toward the red region of the visible spectrum as compared with natural sunlight; and finally, fluorescent ceiling lights, which – unlike incandescent lights – have various colorrendering properties depending on the specified color temperature.[8] When matching the

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shade of artificial teeth in prosthetics, one should perform the assessment in the presence of only 1 light source, as overlapping illumination from different sources may promote metamerism.[8] Five different light resources were teste in the study to assess their effect in shade selection accuracy : natural daylight (sunrise), natural daylight (sunset), white fluorescent ceiling light, room halogen ceiling light (spot light) and office halogen light (the operating light of a dental unit).

Materials and methods

Five different light sources were tested in the study: natural daylight (sunrise), natural daylight (sunset), white fluorescent ceiling light, room halogen ceiling light (spot light) and office halogen light (the operating light of a dental unit). VITA classical Shade guide tabs (16 tabs) have been chosen to be tested in this study (Figure 1) to simulate natural teeth with a known preexisting shade to evaluate the accuracy of electronic shade selection devise ShadeStar (Dentsply - Germany) (Figure 2) in 5 different surrounding light sources. 10 readings (n=10) of each shade tab matching were tested under each surrounding light source. Only 13 shade tabs of the classical shade guide (A1,A2,A3,A3.5,A4,B1,B2,B3,C1,C2,C3,D2,D3) were tested (the remaining dark shades did not respond in all the 5 groups). The study conducted within five days in 2 different timings; sunrise and sunset in the open garden area at 8:30 AM and 5:50 PM respectively, while florescent, room halogen and office halogen were conducted in a closed room area. Each Shade tab was directed toward the light source to be tested while the EasyShade devise is directed toward the middle third of the shade tab as an ideal position to achieve the shade reading viewed at eye level and at arm's length so the most sensitive part of the retina will be used.[9] If the EasySahde reading match the original shade tab, the reading marked as correct otherwise it was marked as incorrect. Data was statistically analyzed by calculating the average percentage of the accurate readings and one way ANOVA at 5% level of significance.

Figure 1. The VITA classical Shade guide used in this study.

Figure 2. The electronic shade guide (ShadeStar) used in this study.

Results

Average percentage of the correct readings for each shade tab under different light sources tested in this study are presented in table 1 & figure 3. Statistical analysis of the data with one-way ANOVA revealed that, there was a statistically significant difference between the 5 light sources being tested in shade matching accuracy readings ($p \leq 0.05$) as shown in table 2 & figure 4. Sunrise light source demonstrated the highest shade selection accuracy percentages while Florescent light source demonstrated the lowest shade selection accuracy percentages in this study as shown in table 1. Table (3) represents the P-Value as per shade tab under the five lighting sources which indicated that only the A2 shade tab exhibited insignificant differences among the 5 light groups being tested.

Shade Tab	Sunrise G1	Sunset G2	Room Halogen G3	Florescent G4	Office Halogen G5
A1	100	90	50	100	100
A2	100	70	90	100	100
A3	100	40	80	70	100
A3.5	100	10	40	0.0	0.0
A4	100	0.0	50	90	0.0
B1	100	100	100	0.0	100
B2	100	100	100	20	40
B3	100	100	100	40	70
C1	100	70	0.0	0.0	80
C2	100	10	0.0	0.0	40
C3	100	0.0	0.0	0.0	0.0
D2	100	0.0	0.0	0.0	90
D3	0.0	0.0	0.0	0.0	100
Mean	92.3077	45.3846	46.9231	32.3077	63.0769
SD	27.735	43.7065	43.2791	42.2599	41.7102

Table 1. The average percentage of the correct readings for each shade tab under the different light sources.

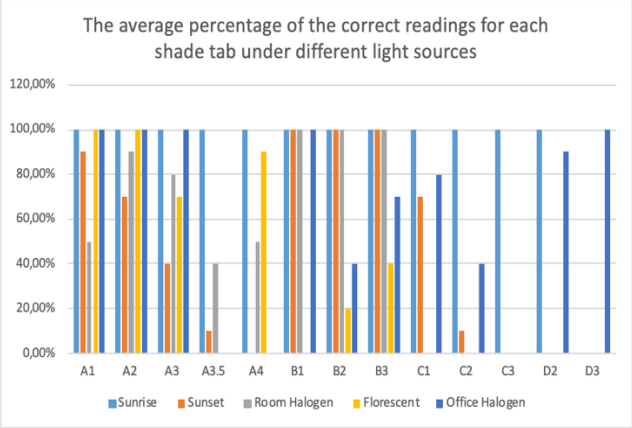

Figure 3. Bar chart representing the average percentage of the correct readings for each shade tab under the different light sources.

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	4	27621.5355	6905.3839	4.2741	0.0041
Within Groups	60	96938.5056	1615.6418		
Total:	64	124560.0411			

Table 2. One-Way ANOVA of the accurate readings for the five light source groups being tested in this study.

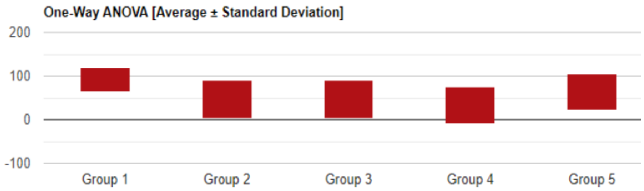

Figure 4. One-Way ANOVA [Average ± Standard Deviation].

Shade Tab	P-Value of 0.05
A1	0.001
A2	0.033
A3	0.006
A3.5	0.000
A4	0.000
B1	0.000
B2	0.000
B3	0.001
C1	0.000
C2	0.000
C3	0.000
D2	0.000
D3	0.000

Table 3. Showing the P-Value of each shade tab under the different five lighting sources.

Discussion

Shade selection is one of the most sensitive steps in fabrication of any dental restoration especially in the visible zone of the mouth. Many variations have been observed in the shades selected by different observers as well as in the case of a single observer matching the shade for the same tooth on different occasions.[10] The use of a pre known or previously identified tab shades by using classical shade guide tabs has simplified the recognition of the correct/incorrect shade registration via the ShadeStar electronic shade guide. Some studies had encountered some problems that might interfere during visual shade selection like color blindness, eyes fatigue and environmental influences. That's why we preferred to use the electronic technique

rather than the visual one.[6, 7, 11, 12] The optimal conditions for tooth shade matching are provided by a light having a color temperature between 5,500 K and 6,500 K, and the Color Rendering Index (CRI) greater than 90. According to the CRI, the sunrise daylight is considered the best because it is closest to emitting the full spectrum of white light as at this time light is most balanced. It is used as the standard by which to judge other light sources and its color temperature is 5500 K. It has CRI close to 100. When matching the shade of artificial teeth in prosthodontics, one should perform the assessment in the presence of only 1 light source, as overlapping illumination from different sources may promote metamerism.[8] The data of this study indicated that, the sunrise light source is the most suitable time for shade selection since it showed the highest accuracy percentage (92.3) and to be more consistent (least SD) in comparison with the other 4 light groups being tested as shown in table 1. This result might be due to the ability of light source to reveal the colors of various objects in comparison with the ideal or natural light source, termed as Color Rendering Index (CRI). It is a scale from 0 to 100 percent indicating how accurate a "given" light source is at rendering color when compared to a "reference" light source. CRI scale from 90-100 is considered the best as in natural sunrise light source, whereas scale of below 90 is not suitable for shade matching selection. Although the sunrise daylight light source is proved to be the most accurate light source for shade selection in our study, the fact remains that it is only available for a relatively short and limited time of the day that might be considered impractical or dead time for dental treatments since most of dental clinics are usually starting their work much later than this time or in the evening using artificial light sources. Therefore it is unreliable for dental shade selection purpose because that request a stable light source that can be offered continuously during the clinic working time. This is where artificial light step in. The data of this study revealed that, the sunset light source is the most suitable time for shade selection since it sunrise showed low accuracy percentage (45.38) tested as shown in table 1.The sunset light source showed a high variance in the accuracy of the readings since it showed a high percentage of correct readings only with A1, B1, B2 and B3 shade tabs (Figure 3). This high variance is mainly depending on the CRI, the wavelengths of the blue and green colors in this time are short and don't penetrate the atmosphere as we need the full spectrum of white light, so it can be considered not reliable in shade selection accuracy as a surrounding light source. Our findings agreed with the findings of Rosenstiel (1995) [13] whom also found that incandescent Light (room halogen G3 and office halogen G5 in our study) emits high concentration of yellow waves. It is not suitable for shade matching since they achieved relatively low shade matching accuracy percentages (46.92 and 63.07 respectively) as shown in table 1. It has low Color Rendering Index (CRI). Fluorescent light (G4) achieved the lowest shade matching accuracy percentage among all the other 4 groups being tested as it emits high concentration of blue waves. Also it is not suitable for shade matching. It has CRI of 50-80. Natural sunrise daylight is considered the best surrounding light source because it is closest to emitting the full spectrum of white light. It is used as the standard by which to judge other light sources. It has CRI close to 100.[13]

Conclusions

The surrounding lighting source significantly affects the clinical shade matching performance of dental professionals.

Natural sunrise daylight is considered the best light source in terms of shade matching accuracy.

Declaration of Interest

The authors report no conflict of interest.

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