Effects of a shade-matching light and background color on reliability in tooth shade selection

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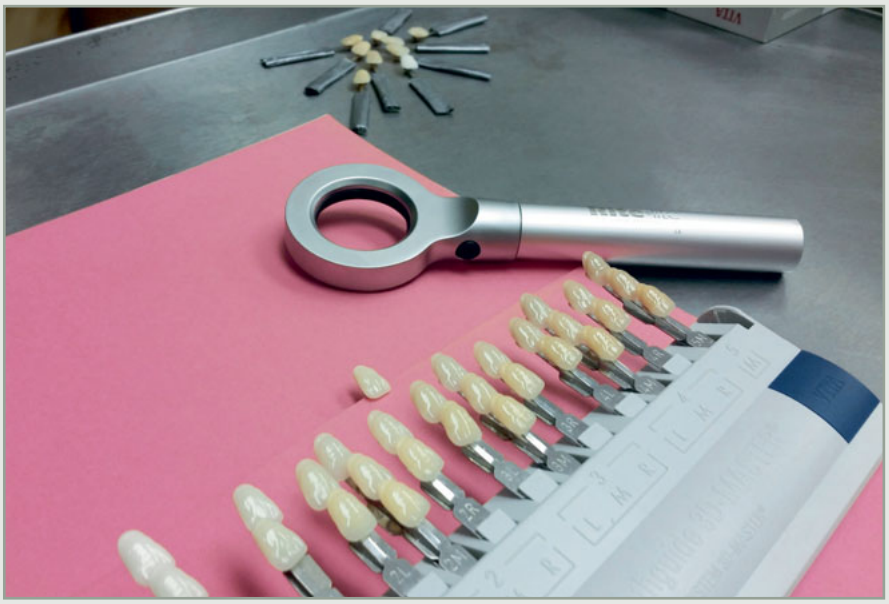
Abstract

Objective: The purpose of this study was to evaluate the effects of a shade-matching light (Rite-Lite-2, AdDent) and different viewing backgrounds on reliability in a test of shade tab matching.
Materials and methods: Four members of the Prosthodontic faculty matched 10 shade tabs selected for a range of shades against the shade guide. All raters were tested for color blindness and were calibrated prior to the study. Matching took place under four combinations of conditions: with operatory light or the shade-matching light, and using either a pink or a blue background. Reliability was quantified with the kappa statistic, separately for agreement of *value*, *hue*, and *chroma* for each shade tab.
Results: In general, raters showed fair to moderate levels of agreement when judging the *value* of the shade tabs, but could not agree on the *hue* and *chroma* of the stimuli. The pink background led to higher levels of agreement than the blue background, and the shade-matching light improved agreement when used in conjunction with the pink but not the blue background.
Conclusions: Moderate levels of agreement were found in matching shade tab *value*. Agreement was generally better when using the pink rather than the blue background, regardless of light source. The use of the shade-matching light tended to amplify the advantage of the pink background.

(Int J Esthet Dent 2018;13:198–206)



Introduction

Tooth shade selection is one of the key parameters in fabricating an esthetically successful restoration.[1] The study of color has therefore received much attention among practitioners and manufacturers.[2]

Color measurement in clinical dentistry can be categorized into two groups: instrumental and visual.[3] The most popular method for shade selection is visual perception.[4-6] Visual color determination is the comparison of a patient's tooth shade with a color reference (shade guide).[1,7-9] The visual perception method may be inconsistent[10] due to the surrounding conditions such as background color, light source, and shade guides, as well as numerous physiological and psychological factors.[8,11,12] Culpepper found disagreements between clinicians when selecting the shade of the same tooth. He concluded that individuals are unable to duplicate their shade selection on different days.[11]

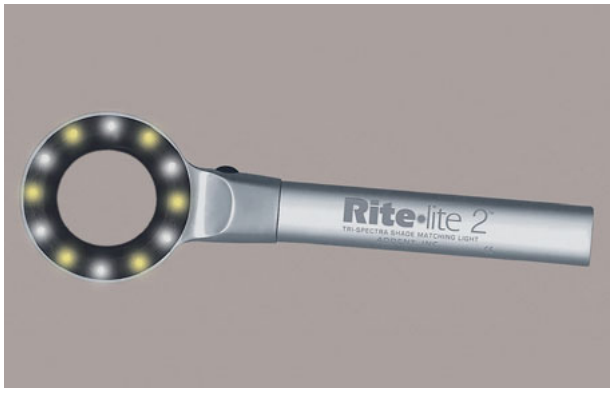


Fig 1 The shade-matching light (Rite-Lite-2, AdDent).

Attempts to standardize tooth shade selection using the visual perception method[13] have shown that lighting conditions and the type of light source are important factors influencing color perception.[14-16] It is recommended that the lighting sources in the operatory and dental laboratory should be a balanced spectrum in the visible range (300 to 780 nm), and color temperature should be approximately 5500°K, with a color rendering index of > 90.[17] Ideally, both clinician and technician should work under similar balanced and full-spectrum lighting conditions to achieve a successful color match and to minimize metamerism.[18]

In the absence of optimum daylight conditions, shade-matching lights have been introduced to the dental industry to standardize the effect of the light source.[16,19] Shade-matching ability is better with a corrected light source than under natural light.[20] Paravina evaluated a visual shade-matching apparatus, Shademat Visual+ (SV+), and concluded that the apparatus enabled better shade-matching than daylight.[21] Curd et al assessed a commercially available light source, Demetron Shade Light (Kerr Corp), and concluded that the shade-matching abilities of dental students were better with a light-correcting source than under natural light.[22] McAndrew et al also concluded that utilizing a shade-matching light improved the shade-matching ability of dental students compared to the traditional method in natural daylight.[23]

Previous studies have found inconsistencies among clinicians in shade matching for the same tooth on different days.[10,24] Therefore, the most reliable

method or instrument for tooth shade selection is controversial.[25]

Rite-Lite-2 (AdDent), a tri-spectra LED shade-matching light, is one of the commercial shade-matching lights available on the market. It has three modes of light for shade selection to simulate different lighting conditions: 1) Color-corrected Light (daylight) 5500°K; 2) Incandescent (room light) 3200°K; and 3) Ambient Light (a combination of room light and daylight) 3900°K.[26] The effectiveness of this shade-matching light has not yet been studied.

The color of the background is also controversial during the visual perception method. Some studies have utilized a gray background for shade selection to reduce eye fatigue.[22,27] Gazing at the color blue has also been recommended.[21] This manufacturer (AdDent) recommends the utilization of pink cards as a background in order to neutralize the extraoral and intraoral color interference.[26]

The purpose of this study was to determine reliability in the matching of shade tabs, and to evaluate the effect of a Rite-Lite-2 shade-matching light (Fig 1) with different viewing backgrounds (pink and blue) on reliability between and within raters.

Materials and methods

Subjects

Raters were four prosthodontists, all faculty members in the Department of Prosthodontics of New York University College of Dentistry. The raters were between 40 and 73 years of age and had 11 to 38 years of experience in dentistry. All successfully completed the Ishihara color blindness test.[28] An informed consent form was obtained from each rater participating in the study, and IRB exemption was granted (IRB #14-10355).

Materials

Ten shade tabs were selected from Vitapan 3D-Master shade guide (Vita Zahnfabrik) so that *hue*, *value*, and *chroma* were distributed equally. To ensure blinding of all participants, each shade tab ID was covered with tape, and a code was assigned to each. Shade selections were made using either operatory lighting (fluorescent linear lamp [T8-4100°K; CRI = 86; GE Lighting] with the help of a dental chair light [Philips: 14623-95W-G6.35-17V-3400°K]) or the Rite-Lite-2. The raters were free to toggle between the modes. Backgrounds were colored letter-size paper (11 × 8.5 inches), either blue or pink.

Method

The raters were initially calibrated. The calibration was performed by having each rater organize a random presentation of the 10 shade tabs by increasing levels of *value*, *chroma*, and *hue*. The raters were given feedback on the proper order. All raters were able to organize the shade tabs in their first attempt. For the rating task, the 10 shade tabs were randomly placed on a benchtop. For each tab, the rater chose the best match from the Vitapan 3D-Master shade guide, and the data collector recorded that response. All ratings were made within 90 s. All sessions were

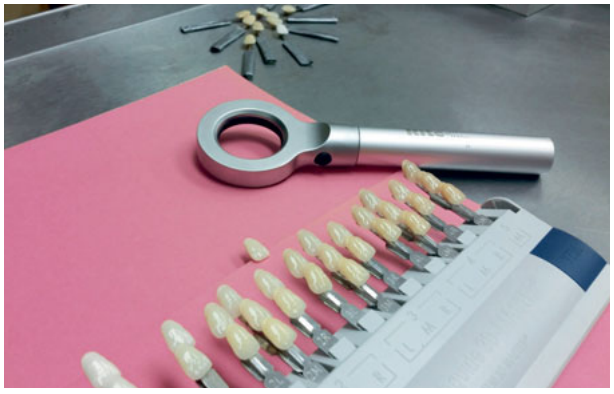


Fig 2 The setup of the study using the shade-matching light against the pink background.

completed in the same windowless operatory, and the raters were blinded to their previous selection and each other's selections.

This matching task was completed under four conditions in which the light source and background color were varied: 1) traditional method, where the raters selected the shade of the shade tabs under the light condition of the operatory, against a blue background; 2) same as for (1) but using a pink background; 3) using the shade-matching light against a blue background; and 4) using the shade-matching light against a pink background (Fig 2).

Data analysis

The shade tabs in the Vitapan 3D-Master shade guide consist of three codes that represent *value*, *hue*, and *chroma*, respectively (eg, 4M1.5). Analysis evaluated the agreement for each of these constituent qualities of color. Statistical analyses were performed using IBM SPSS, version 22 (IBM Corp). The reliability among the raters was assessed with the kappa statistic, and its 95% confidence limits were estimated using a bootstrap technique with 1000 replications. Significance (defined as a type 1 error rate less than 5%) was indicated when the kappa determined under one combination of conditions was outside the limits of the kappa determined under any other combination of conditions.

Results

Value

Table 1 shows kappa and its 95% confidence limits for ratings of *value* in each combination of light source and background material. In general, the kappa of 0.57 indicates a moderate level of agreement averaged over all conditions, and each combination of conditions produced confidence limits excluding 0, indicating better than chance levels of agreement among raters ($P < 0.05$). In addition, the pink background resulted in greater agreement than the blue background (k = 0.67 vs 0.46), regardless of light source ($P < 0.05$). On the other hand, there was no statistical difference between light sources, and while the Rite-Lite-2 produced greater agreement than the operatory lights against the pink background (k = 0.76 vs 0.59), this difference was not statistically significant ($P > 0.05$). Thus, the shade tab *value* provides raters with a cue that leads to moderate levels of agreement.

Hue

Table 2 shows kappa and its 95% confidence limits for ratings of *hue* in each

Table 1 Agreement (kappa) for *value* as a function of light source and background color. Note that all confidence limits exclude 0, indicating better than chance levels of agreement, and that the kappa for the pink background (total) is not included in the confidence limits of the blue background ($P < 0.05$)

		Kappa value	Std error	95% Confidence Interval	
Background	**Lighting**			**Lower**	**Upper**
Blue	Operatory lights	0.446	0.114	0.210	0.659
	Rite-Lite-2	0.484	0.108	0.243	0.657
	Total	0.464	0.080	0.300	0.603
Pink	Operatory lights	0.590	0.108	0.361	0.780
	Rite-Lite-2	0.757	0.089	0.565	0.925
	Total	0.672	0.071	0.522	0.798

Table 2 Agreement (kappa) for *hue* as a function of light source and background color. Note that many confidence limits include 0, indicating chance levels of agreement, and that even the highest kappa is < 0.4, indicated at most fair levels of agreement on the basis of this characteristic

		Kappa value	Std error	95% Confidence Interval	
Background	**Lighting**			**Lower**	**Upper**
Blue	Operatory lights	0.340	0.117	0.118	0.559
	Rite-Lite-2	-0.052	0.119	-0.275	0.183
	Total	0.149	0.080	-0.009	0.303
Pink	Operatory lights	0.220	0.117	-0.028	0.433
	Rite-Lite-2	0.382	0.112	0.163	0.600
	Total	0.299	0.080	0.139	0.449

combination of light source and background material. In general, the kappa of 0.22 indicates only poor levels of agreement averaged over all conditions, and many combinations of conditions produced only chance levels of agreement among raters (confidence limits include 0). There were no statistical differences as a function of light source ($P > 0.05$) or background, although the pink background resulted in greater agreement than the blue background

Table 3 Agreement (kappa) for *chroma* as a function of light source and background color. Note that most confidence limits do not include 0, indicating more than chance levels of agreement, but that even the highest kappa is < 0.5, indicating at most a moderate level of agreement on the basis of this characteristic

		Kappa value	Std error	95% Confidence Interval	
Background	**Lighting**			**Lower**	**Upper**
Blue	Operatory lights	0.0231	0.096	0.043	0.428
	Rite-Lite-2	0.048	0.084	-0.109	0.218
	Total	0.141	0.064	0.018	0.274
Pink	Operatory lights	0.179	0.089	0.000	0.351
	Rite-Lite-2	0.445	0.098	0.250	0.637
	Total	0.315	0.066	0.188	0.442

(0.05 < *P* < 0.10). Thus, the shade tab *hue* does not appear to provide a useful cue for raters.

Chroma

Table 3 shows kappa and its 95% confidence limits for ratings of *chroma* in each combination of light source and background material. In general, the kappa of 0.23 indicates only poor levels of agreement averaged over all conditions, although most combinations of conditions produced above chance levels of agreement among raters. While agreement was not strong, the pink background resulted in greater agreement than the blue background (k = 0.32 vs 0.14), regardless of light source (*P* < 0.05). While the level of agreement was still only fair, the Rite-Lite-2 produced greater agreement than the operatory lights against the pink background (k = 0.45 vs 0.18; *P* < 0.05). Thus, the shade tab *chroma* also does not appear to provide a useful cue to raters.

Discussion

The observer's color perception plays an important role in shade selection.[20] Factors affecting the color perception of an object are color blindness, age, experience, fatigue, surrounding color, background, light source, surface texture, etc.[22,29] It has been suggested in the literature that the utilization of corrected light devices or shade-matching lights will improve shade selection.[11,13,16,22,23,30,31] The results of this study revealed that utilizing the shade-matching light increased the kappa indices and improved the reliability of the shade selection. Except for *chroma*, these results were not statistically significant. The range of kappa indices in this

study were within the range of the other studies,[32] except for *hue* and *chroma* utilizing a blue background. The overall highest kappa index was for *value*, which is due to the fact that the human eye can detect differences in *value* more than it can in *hue* or *chroma*.[33]

According to the manufacturer (Ad-Dent), utilizing the pink cards neutralizes the color and prevents eye fatigue.[26] However, some studies recommend neutral gray as an ideal background for shade selection.[22,27,34] Gray does not have any complementary color and is restful to the eyes.[35]

Blue has also been recommended. Since blue and yellow are complementary colors, gazing at blue may lead to blue fatigue and increase yellow-orange sensitivity, which is the dominant hue in teeth.[21] The results of this study found that the combination of the shade-matching light and the pink cards increased the reliability of the shade selections, especially for *value*.

Unlike most of the shade guides, eg, Vita Classical (Vita Zahnfabrik) and Chromascop (Ivoclar Vivadent), the Vita 3D-Master Shade system is arranged based on *value* rather than on *hue* or *chroma*. Preston and Bergen recommended that the shade selection should match the *value*.[36] It is reported that this shade guide provides consistent and more repeatable results.[37,38]

Conclusions

This study compared the visual perception of a standard light source and a corrected light device with blue and pink backgrounds within four raters. It was concluded that the visualization of a corrected light device (Rite-Lite-2) against a pink background increased the reliability of shade selection.

Conflict of interest

The authors declare no conflicts of interest. This research was carried out without funding.

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