Restor Dent Endod. 2023 Nov;48(4):e40
https://doi.org/10.5395/rde.2023.48.e40
eISSN 2234-7666

Research Article

Check for updates

Effects of eye dominance on shade matching and color perception among the dentist population

Pattnaik Kalyani [1], **Kannan Subiksha** [1], **Amit Jena** [1*], **Govind Shashirekha** [2], **Saumyakanta Mohanty** [1], **Gaurav Sharma** [3]

[1]Department of Conservative Dentistry and Endodontics, Sriram Chandra Bhanja Dental College & Hospital, Odisha, India
[2]Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Siksha 'O' Anusandhan (Deemed to be) University, Odisha, India
[3]Department of Public Health Dentistry, Sriram Chandra Bhanja Dental College & Hospital, Odisha, India

Received: Jun 16, 2023
Revised: Sep 26, 2023
Accepted: Oct 17, 2023
Published online: Nov 9, 2023

Citation
Kalyani P, Subiksha K, Jena A, Shashirekha G, Mohanty S, Sharma G. Effects of eye dominance on shade matching and color perception among the dentist population. Restor Dent Endod 2023;48(4):e40.

***Correspondence to**
Amit Jena, MDS
Department of Conservative Dentistry and Endodontics, Sriram Chandra Bhanja Dental College & Hospital, Cuttack 753007, Odisha, India.
Email: amitjena@yahoo.com

Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Conceptualization: Kalyani P, Jena A; Data curation: Subiksha K, Sharma G; Formal analysis: Sharma G; Investigations: Shashirekha G; Methodology: Kalyani P,

ABSTRACT

Objectives: The purpose of this study was to evaluate the influence of eye dominance on color perception, and shade matching.
Materials and Methods: A total of 104 participants were selected for the study. There were 3 groups: Group I: 3rd and 4th year dental students and interns ($n = 40$); Group II: postgraduates ($n = 34$); Group III: senior residents and faculty members (≥ 6 years of clinical experience) ($n = 30$). All participants were evaluated for congenital color blindness with Ishihara plates, their dominant eye with Mile's test, and their color perception with the Farnsworth-Munsell 100 hue test. The shade guide test was used for shade matching with a second corresponding set of Vitapan classical shade guides.
Results: The results of Mile's test revealed that 60.6% were right-eye dominant and 39.4% were left-eye dominant. There was a statistically significant difference among all participants between the dominant eye and the non-dominant eye in shade matching.
Conclusions: The dominant eye has a positive effect on shade matching and the ability to match shades becomes better with an increase in clinical experience.

Keywords: Clinical experience; Color; Color perception; Eye dominance; Shade matching

INTRODUCTION

Smile is one of the most important esthetic features that enhances a person's confidence and self-esteem. Esthetics in dentistry has come a long way with numerous procedures and advancements. Irrespective of the procedure, shade matching is an inevitable and highly challenging step. Clinically, the success of a restoration is decided by numerous factors, but it is truly accomplished by the patient's acceptance. More than 80% of patients were reported to be aware of the shade mismatch with an anterior metal-ceramic restoration to the adjacent natural tooth [1]. This fact reveals the significance of shade selection in an esthetic restorative procedure. The common methods of shade selection can be grouped into 2 categories: subjective (visual) and objective (instrumental) methods. Subjective manual selection with a shade guide is the most common approach [2]. Colorimeters and spectrophotometers have been used for objective shade selection [3].

Subiksha K; Validation: Jena A, Shashirekha G; Writing- Original draft: Kalyani P, Subiksha K; Writing- Review and editing: Jena A, Shashirekha G; Supervision: Mohanty S; Project administration: Kalyani P, Jena A, Mohanty S.

ORCID iDs
Pattnaik Kalyani
https://orcid.org/0000-0002-1861-476X
Kannan Subiksha
https://orcid.org/0000-0002-3052-6738
Amit Jena
https://orcid.org/0000-0002-4522-6519
Govind Shashirekha
https://orcid.org/0000-0003-4992-3087
Saumyakanta Mohanty
https://orcid.org/0000-0002-5609-5091
Gaurav Sharma
https://orcid.org/0000-0002-6699-3477

Color perception is the ability of the eye, excited by light containing different wavelengths, to discriminate between different colors. Two types of photoreceptors are present in our retina for perceiving color: rods and cones. Rods are mainly helpful in vision at low light (scotopic vision) while cones are active in bright light conditions (photopic). Both receptors contain a pigment that absorbs color and helps in perceiving objects. Most of the cones are distributed in the retina's center, thus contributing to a majority of the color perception [4]. For an accurate representation of every color that the human eye can perceive, there are 2 color metric systems: 1) Ciecolor space system (combination of red/green/blue values plotted on a 3D space) and 2) Munsell color system (based on hue, chroma, and value) [3].

Eye dominance is the tendency to prefer visual sensations in one eye more than the other eye. The images are seen more clearly and larger while viewing with the dominant eye and are found to be superior when compared to the non-dominant eye in visual acuity and motor functions [5]. In dentistry, from a selection of shades to restoring a tooth, proper functioning of the visual acuity is important; thus, identifying the dominant eye is crucial.

For accurate shade matching, knowledge of eye dominance and color blindness is of the utmost significance. In this study, dental students and clinicians with varying degrees of clinical experience were evaluated for color blindness, the effect of eye dominance on color perception, and shade matching. The null hypothesis of this study was that eye dominance would not influence color perception and shade matching.

MATERIALS AND METHODS

The study was conducted at Sriram Chandra Bhanja Dental College and Hospital, Cuttack and Institute of Dental Sciences, Bhubaneswar situated in Odisha, India. The study protocol was approved by the Institutional Review Board (approval No. SOA/IDS/IRB 2023/IA). A total of 124 participants provided informed consent. Inclusion criteria: Undergraduates (3^{rd}, 4^{th}-year dental students and interns), Postgraduates, senior residents, and faculty members. Participants with normal color vision were assessed by the Ishihara color blindness test (**Figure 1**). Exclusion criteria: participants with a history of ocular surgery, strabismus, and retinal pathology and participants who would not agree to participate in the test.

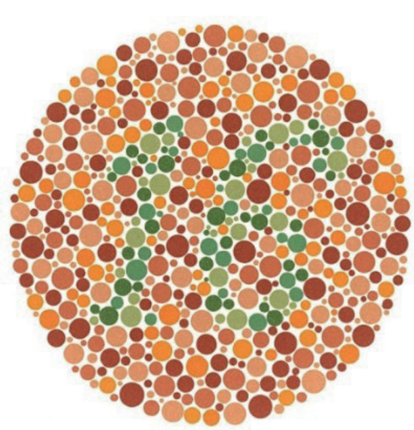

Figure 1. Representative image of Ishihara color book for the assessment of color blindness.

The study was conducted in a well-ventilated room (10:00 a.m. to 2:00 p.m.) with access to natural daylight. Each participant was instructed to use the shade guide placed on the table in front of the window to match the color. The neutral grey color of the room's walls helped reduce eye strain during the test. For the Farnsworth-Munsell (FM) 100 hue test, the laptop (Asus VivoBook X515EA) was constantly charged at 220 V, the screen brightness was standardized to 70 percent, and the distance from the screen was maintained at 50 cm for all participants.

Color blindness test using Ishihara plates

Participants were asked to complete the Ishihara test for color blindness, in which the Ishihara color book consisted of 38 plates (**Figure 1**). Each participant had 5 seconds to identify the number on the plate. Twenty participants who were unable to identify the numbers were eliminated from further testing.

The participants (N = 104) were further divided into 3 groups based on their years of clinical practice/training. Group I: 3rd, 4th BDS and Interns (n = 40); Group II: postgraduates (n = 34); Group III: senior residents and faculty members with ≥ 6 years of clinical exposure (n = 30). As described below, these participants were subjected to a dominance test, a color perception test, and a shade guide test.

Dominant eye assessment using Mile's test

Each participant performed the Mile's test according to Elghorab *et al.* [5]. Each participant was instructed to extend his or her arms in front of his or her body and join his or her fingers together to form a small triangle (**Figure 2**). Each participant was instructed to look through the triangle with both eyes open, focus on a dot placed on the wall approximately 10 feet (3 meters) away, and attempt to keep their hands still. The participants were then instructed to alternately close their eyes. The dominant eye was the eye that observed the dot.

Color perception assessment by FM 100 hue test

The FM 100 hue color perception test was administered online via the www.xrite.com website (**Figure 3**). This examination contains 4 rows of distinct color combinations. In each row, the first and last boxes of each color are fixed. Participants were instructed to organize the boxes in each row by hue, value, and chroma. The test was conducted with the dominant eye (the

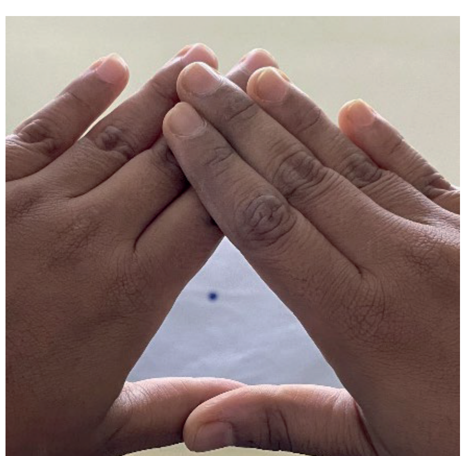

Figure 2. Representative image of Mile's test for eye dominance.

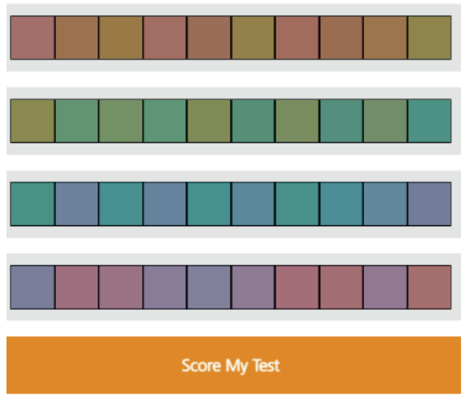

Figure 3. Representative image of Farnsworth-Munsell 100 hue test for the color perception assessment.

non-dominant eye was closed) and then repeated with the non-dominant eye (the dominant eye was closed). After the test has been completed, the system automatically generates a total error score. The obtained score was inversely proportional to the ability to perceive color (zero being the perfect score).

Shade guide test using Vitapan classical shade guide

The shade codes were concealed on 5 tabs (A2, A3.5, B1, C2, and D3) from the Vitapan (VITA Zahnfabrik) classical shade guide (**Figure 4**). The participants were instructed to match the hidden tabs with a second complete set of the Vitapan classical shade guide. The test was conducted with the dominant eye (the non-dominant eye was closed) and then repeated with the non-dominant eye (the dominant eye was closed). The percentage was used to calculate the score. A higher percentage indicated that the participants correctly matched a greater number of tabs.

Statistical analysis

The data obtained were entered into a Microsoft Excel Worksheet and analyzed using Statistical Package for Social Sciences (SPSS, Version 27.0.; IBM Corp., Armonk, NY, USA). The normal distribution of data was confirmed with Shapiro-Wilk's test and appropriate non-parametric

Figure 4. Representative image of Vitapan classical shade guide for the analysis of shade where 5 tabs were kept concealed.

https://doi.org/10.5395/rde.2023.48.e40

tests were employed. Mean, median, and standard deviation were computed for all continuous variables. Frequencies and Proportions were computed for categorical variables.

Comparison of the mean difference between the dominant and non-dominant eye was done using the Wilcoxon Signed Rank Test for Paired samples independently amongst the groups. $p < 0.05$ was considered significant for all statistical inferences.

RESULTS

The Ishihara test revealed that 20 participants were color-blind and were not subjected to an eye dominance test. The distribution of the mean age (in years) among the groups was found to be 28.75 ± 7.27 years. Group 1(Undergraduates), Group 2(Postgraduates), and Group 3(Senior Residents and Faculties) has respective mean scores of 23.45 ± 1.79, 26.91 ± 1.54, 37.90 ± 7.17 years respectively. Considering the gender distribution, out of 104 participants 33 (31.7%) were males and 71 (68.3%) were females.

41 (39.4%) of the participants had left eye dominance, whereas 63 (60.6%) had right eye dominance, as determined by Mile's test (**Table 1**). FM-100 hue test results: The color perception average values for the dominant eye were 3.92 ± 5.01 and for the non-dominant eye they were 4.5 ± 5.26. There was no significant difference between the dominant and non-dominant eyes among individual groups or overall participants ($p = 0.12$) (**Table 2**). Shade Guide Test Results: The color perception average values for the dominant eye were 30.96 ± 24.43 and for the non-dominant eye were 20.58 ± 20.75. There was no statistically significant difference between the dominant eye and the non-dominant eye in Groups I and II, but there was a statistically significant difference in Group III ($p = 0.001$) and among all participants ($p = 0.001$) (**Table 3**).

Table 1. Dominant eye assessment using Mile's test

Dominant eye	Group I	Group II	Group III	Overall
Left	20 (50.0)	12 (27.3)	9 (30.0)	41 (39.4)
Right	20 (50.0)	22 (72.7)	21 (70.0)	63 (60.6)

Values are presented as number of participants (%).

Table 2. Mean and standard deviation (SD) of error score in Farnsworth-Munsell (FM) 100 hue test

Group	FM 100 dominant	FM 100 non-dominant	*p* value
I	1.90 ± 2.75 (1)	2.40 ± 2.68 (2)	0.18
II	2.94 ± 3.59 (2)	3.47 ± 4.95 (2)	0.32
III	7.73 ± 6.53 (6)	8.47 ± 6.09 (8)	0.38
Overall	3.92 ± 5.01 (2)	4.5 ± 5.26 (2)	0.12

Values are presented as mean ± SD (median).

Table 3. Mean and standard deviation (SD) of error score in Shade Guide Test

Group	Shade dominant	Shade non-dominant	*p* value
I	29.00 ± 25.19 (20)	19.50 ± 23.74 (20)	0.06
II	24.12 ± 22.97 (20)	19.41 ± 21.16 (20)	0.32
III	41.33 ± 22.24 (40)	23.33 ± 15.83 (20)	0.001
Overall	30.96 ± 24.43 (20)	20.58 ± 20.75 (20)	< 0.001

Values are presented as mean ± SD (median).

https://doi.org/10.5395/rde.2023.48.e40

DISCUSSION

The null hypothesis that eye dominance would have no effect on color perception was partially accepted because the FM 100 hue test did not produce significant results, but eye dominance was found to have a significant effect on shade matching. The second null hypothesis was rejected because the group with more clinical experience (group III) played a significant role in shade matching.

Numerous variables, including age, gender, clinical experience, lighting conditions, and physiological characteristics of the observer, make it difficult to choose the correct shade [6]. Due to aging, ocular factors such as lenses, cones, and a reduction in the size of the pupil affect color perception [7]. Other optical factors such as translucency, fluorescence, opalescence, and metamerism also play a significant role in color perception [8,9].

Color blindness is a significant factor that affects shade matching. The Ishihara test, considered the gold standard [10] allows for a rapid diagnosis of congenital color deficiency. In the present study, the participants took the online examination where the distance between the participant and the monitor was constant.

Numerous techniques exist for identifying the dominant eye, such as; Dolman's method, the Mile's test, the Porta test, the Pinhole test, the Ring Test, etc. This study utilized Mile's test because it is simple to execute and could be replicated multiple times.

Contrary to the findings of this study, Elghorab *et al.* [5] found that with the dominant eye, men performed significantly better than women. However, for eye dominance, our research did not reveal any age and gender-based differences.

The clinical experience of a dental professional is assumed to be dependable, and has a positive effect on accurate shade-matching ability [11]. Though some studies found no correlation between clinical experience and color matching; few studies have found contradictory evidence that clinical experience improves the ability to match shades. In this study, the experienced group (≥ 6 years, Group III) matched shades more accurately, which may be attributed to the years of clinical experience [12-16]. In addition, studies have demonstrated that educational training results in superior color-matching skills [17,18].

In our study, the FM 100 hue test was assigned to evaluate color perception as it is the most sensitive test [5]. This examination is available both as a manual kit, and an online software. Compared to the manual method, the free and user-friendly online version (available at www.xrite.com) was used. The obtained results are easily reproducible, highly accurate, and require less time. Elghorab *et al.* [5] used the FM 100 hue test to conclude that eye dominance played a significant role in color perception among male participants, whereas Garg *et al.* [19] performed visual shade matching, and concluded that shade matching was accurate with the dominant eye, and clinical experience did not play a significant role in shade matching. No earlier studies determined the combination of the FM 100 hue test, and the shade guide test that was used in the present study, and it was determined that the FM 100 hue test had no statistically significant correlation with eye dominance. Also, when we considered shade matching, the dominant eye performed better marginally in the 2 groups and significantly in the third group. Few other studies also supported the findings of the present study stating that there was no significant difference in color discrimination between the dominant and the non-dominant eye [20,21].

This study used the Vitapan Classical shade guide consisting of 16 tabs arranged according to chroma or value. The selected 5 shade tabs (A2, A3.5, B1, C2, and D3) are the most frequently found shades in clinical dentistry [19]. Using the Vita Classical shade guide on a different group of participants, a comparative study revealed similar hypotheses and indicated that; women and participants with a lower Total Error Score performed better at matching shades, but were unable to differentiate value [22].

Around 30 years of age due to a change in the absorption of light by the ocular apparatus there is a gradual reduction in pupil size and color perception, but it does not manifest itself until the sixth decade of life [1,15]. If an older population of dental professionals were studied, the physiological impact of age may be overlooked due to the years of dental shade-matching experience.

Women have traditionally been thought to have better color vision and better shade matching than men. However, studies have failed to find a substantial influence of gender on shade matching, and the ability to discriminate tooth shades appears to be similar for men and women [15].

The disparity in age and gender distribution was a potential limitation of the study. Moreover, shade tabs were matched with another set of shade tabs instead of natural teeth. Additional research can be conducted in which the shade tabs are used to match the color of natural teeth. Furthermore, additional research is required to compare the visual shade guide system with the instrumental shade guide system.

CONCLUSIONS

Within the scope of this study, the dominant eye performed better for color perception and shade matching. With the increase in clinical experience (≥ 6 years), shade matching was significantly better with the dominant eye. Knowledge of the dominant eye is important in restorative dentistry, and necessitates the combination of Miles test, FM 100 hue test, and shade guide test to determine the role of ocular dominance.

REFERENCES

1. Imbery TA, Killough C, Baechle MA, Hankle JL, Janus C. An evaluation of factors affecting dental shade matching in first-year dental students. J Prosthet Dent 2022;128:489-495.
PUBMED | CROSSREF
2. Ragain JC. A review of color science in dentistry: shade matching in the contemporary dental practice. J Dent Oral Disord Ther 2016;4:1-5.
CROSSREF
3. Ragain JC. A review of color science in dentistry: colorimetry and color space. J Dent Oral Disord Ther 2016;4:1-5.
CROSSREF
4. Ragain JC. A review of color science in dentistry: the process of color vision. J Dent Oral Disord Ther 2015;3:1-4.
CROSSREF
5. Elghorab HF, Hammad IA, Azer A, Nassif MA. The effect of eye dominance in color perception among dental students with normal color vision. Alex Dent J 2021;46:127-131.
6. Carsten DL. Successful shade matching--what does it take? Compend Contin Educ Dent 2003;24:175-178.
PUBMED

 https://doi.org/10.5395/rde.2023.48.e40

7. Shinomori K. Ageing effects on colour vision-changed and unchanged perceptions. J Int Color Assoc 2005;8:7-12.
8. Vadher R, Parmar G, Kanodia S, Chaudhary A, Kaur M, Savadhariya T. Basics of color in dentistry: a review. IOSR J Dent Med Sci 2014;13:78-85.
CROSSREF
9. Sikri VK. Color: implications in dentistry. J Conserv Dent 2010;13:249-255.
PUBMED | CROSSREF
10. Dain SJ. Clinical colour vision tests. Clin Exp Optom 2004;87:276-293.
PUBMED | CROSSREF
11. Cardoso JA, Almeida PJ, Fischer A, Phaxay SL. Clinical decisions for anterior restorations: the concept of restorative volume. J Esthet Restor Dent 2012;24:367-383.
PUBMED | CROSSREF
12. Aswini KK, Ramanarayanan V, Rejithan A, Sajeev R, Suresh R. The effect of gender and clinical experience on shade perception. J Esthet Restor Dent 2019;31:608-612.
PUBMED | CROSSREF
13. Haddad HJ, Jakstat HA, Arnetzl G, Borbely J, Vichi A, Dumfahrt H, *et al*. Does gender and experience influence shade matching quality? J Dent 2009;37 Supplement 1:e40-e44.
PUBMED | CROSSREF
14. Yılmaz B, Irmak Ö, Yaman BC. Outcomes of visual tooth shade selection performed by operators with different experience. J Esthet Restor Dent 2019;31:500-507.
PUBMED | CROSSREF
15. Çapa N, Malkondu O, Kazazoglu E, Calikkocaoglu S. Evaluating factors that affect the shade-matching ability of dentists, dental staff members and laypeople. J Am Dent Assoc 2010;141:71-76.
PUBMED | CROSSREF
16. Simionato A, Pecho OE, Della Bona A. Efficacy of color discrimination tests used in dentistry. J Esthet Restor Dent 2021;33:865-873.
PUBMED | CROSSREF
17. Samra AP, Moro MG, Mazur RF, Vieira S, De Souza EM, Freire A, *et al*. Performance of dental students in shade matching: impact of training. J Esthet Restor Dent 2017;29:E24-E32.
PUBMED | CROSSREF
18. Clary JA, Ontiveros JC, Cron SG, Paravina RD. Influence of light source, polarization, education, and training on shade matching quality. J Prosthet Dent 2016;116:91-97.
PUBMED | CROSSREF
19. Garg A, Raura N, Arora A, Shenoy R, Thomas M. Effect of ocular dominance, clinical experience, and sex on the accuracy of shade selection. Quintessence Int 2022;53:320-327.
PUBMED
20. Costa MF, Ventura DF, Perazzolo F, Murakoshi M, Silveira LC. Absence of binocular summation, eye dominance, and learning effects in color discrimination. Vis Neurosci 2006;23:461-469.
PUBMED | CROSSREF
21. Opper JK, Volbrecht VJ. Binocular vs. monocular hue perception. Vision Res 2017;131:1-15.
PUBMED | CROSSREF
22. Imbery TA, Tran D, Baechle MA, Hankle JL, Janus C. Dental shade matching and value discernment abilities of first-year dental students. J Prosthodont 2018;27:821-827.
PUBMED | CROSSREF