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Original research article

COMPARISON OF VISUAL SHADE MATCHING ABILITY OF UNDERGRADUATE STUDENTS IN DIFFERENT LIGHTING CONDITIONS

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Abstract: *Comparison of visual shades is essential in careers, such as dentistry since consistent color duplication is crucial for appearance. People have the skills to match shades in many aspects and lighting is among the most important factors that affect the versatility. Knowledge of how different lighting environments impact the ability of students to match shades visually can enhance educational approaches.* ***Objectives:*** *To compare the degree of the actual successful attempts of the subjects at the anatomic facial area and hair visual shade matching while being tested under different lighting conditions and superimpose the findings to determine the extent of influence of the conditions on the results.* ***Methods:*** *This descriptive cross-sectional study was conducted at the Department of Prosthodontics, Bacha Khan College of Dentistry from May 2024 to October 2024. The target population of this study was composed of three hundred undergraduate students and participants included one hundred and fifty students each undertaking visual shade-matching exercises under three distinct light sources; natural daylight, fluorescent, and LED lighting. Standardized shade tabs were used/ offered to the participants, who were asked to match them under those lighting. Accuracy data were collected, and thus analyses of the performances under various lighting conditions were made. The quantitative data variability was analyzed by using SD and p-value for statistical significance.* ***Results:*** *out of the 138 participants, those under natural daylight had the highest mean accuracy of 85.3% (SD ±5.4) out of 138 participants. Under fluorescent lighting, the percentage dropped to 78.1% (SD±6.1) with a higher standard deviation and highest error frequency. The application of LED lighting produced a mean accuracy of 82.7% (SD ± 5.9). Analysis of the result revealed that there was a statistically significant difference ($p < 0.05$) across all lighting conditions with natural daylight being preferable for shade matching.* ***Conclusions:*** *In particular, the findings reveal that identifying the correct shade under natural daylight is the best in comparison to other lighting conditions and those scores are worst under fluorescent light. Optimal lighting conditions used during the training can improve students' learning performance in shade-matching tasks.*

Keywords: Lighting and matching shades, characteristics of the human body, realism, and teeth.

Introduction

The ability to visually match shade is a basic concept that always comes under the operative protocols that need to be followed in restorative dentistry, and more especially in anterior cases. Insight into the correct shade selection is important as it contributes to the creation of restorations that mimic the adjacent dentition. Solutions of different shades may result in patient dissatisfaction and therefore require changes of the restorative replacements which are time-consuming and expensive in treatment. Several parameters affect shade matching, such as the clinician's experience or poor-quality shade guides and lighting conditions in which matching is performed (1). However, among these factors, we can mention that lighting is of special significance because it affects the evaluation of color perception. Color perception is relative to the ability to see an object as it is in the presence of a particular light source. This is because various types of light emit different spectra in the lighted object and cause relative differences in colors. Natural daylight, fluorescent lighting, and LED lighting are most popular and widely used in dental clinics and laboratories and each of these lights possesses certain characteristics or factors that affect the shade matching determinations (2). Midday natural light is preferred during shade selection since a full-spectrum white light source enables better shade discrimination when compared to artificial light (3). But the natural light is not always available or convenient to use in clinical establishments due to time factors, place, or weather conditions. It has been determined that fluorescent lighting has a lower CRI than daylight: this kind of lighting has been traditionally the most frequently used kind of indoor lighting in dental offices. This lower CRI indicates that the natural appearance of an object under fluorescent lamps is not as realistic; this can pose problems for the people who depend on this lighting system to match shades (4, 5). Some researchers have shown that under fluorescent lights, colors tend to look more yellow or green, thus causing one to select the wrong shade (6). In contrast, LED lighting is gradually seen in the modern dental clinic due to the efficiency of energy and service life. LED lights have a higher CRI than any fluorescent lights, which makes them a slightly better solution for shade matching when artificial light is used, such as during the evening (7). While LED lights are known to have considerably higher Coefficients of Raising (CRI), these can have certain constraints, most predominantly in recreating the entire range of daylight (8). This poses a problem to dental practitioners and learners who require an understanding of how certain lighting conditions influence their vision of the shades. From the results obtained from the undergraduate dental students, the main findings show that shade matching of dental materials is a skill that can be learned through practice and mastering the different lighting

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conditions. At the same time, it may be challenging for students to discern what shades that surround them can affect their ability to select the right type of light (9). There is therefore need to evaluate how these lighting conditions affect the performance of dental students during shade-matching skills to enhance their training. Prior studies, which have evaluated the performance of the clinicians with different lighting conditions, revealed that this clinician achieved the best accuracy under natural daylight illumination (10). However, there is little research on the effects of lighting on undergraduate students as compared to postgraduate students because they are relatively inexperienced (11, 12). In this study, the researcher wants to assess the ability of undergraduate dental students in visual shade matching under natural daylight, fluorescent light, and LED light with a view of knowing which lighting condition offers the best result. We speculate that natural daylight will give the highest degree of shade-matching accuracy, while fluorescent lighting will give the lowest.

Methodology

The present study was a descriptive cross-sectional study carried out for six months in the Department of Prosthodontics, Bacha Khan College of Dentistry. The study aimed to evaluate the shade-matching accuracy of undergraduate students under different lighting conditions: There are varied types of lighting including natural lighting, fluorescent lighting, and LED lighting. There with recommend a desired sample size of 138 participants was obtained through non probability consecutive sampling technique. Overall, the subjects were randomized into three groups of approximately equal size, each of which underwent one of the experimental lighting conditions. Shade tabs were standardized and students were told to equate the shades visually using the set lighting condition. Participant attempts were coded as hits or misses for each stimulus according to the following markers. Shade-matching accuracy data collected, and the difference in each group compared, where the paramount importance in data acquisition was placed on whether the results were consistent with each lighting examined.

The structured observational data collection method was used in this study. Details on each participant's attempt at shade-matching were captured during the exercise with notes taken on the ability to match between natural daylight, fluorescent and LED lighting conditions. Independent assessors recorded whether the participant matched with the right colour using the defined shade tab, which provided the logical foundation for further quantifiable evaluation.
Data were analyzed descriptive and inferential using Statistical Product and Service Solutions (SPSS) version 24.0. In descriptive statistics the mean level of accuracy and standard deviation for each lighting condition was determined. Through an alpha level of <0.05 a margin was set to test for statistical significance while comparing lighting types' accuracies to offer the needful assessment of the impact on the shade match performance.

Results

The mean of 82.2 per cent (SD±6.9) of correct shade matches, no significant difference was found between both types of lighting conditions in this study of 138 students. The first set of natural lighting group showed the least variability and the best compliance with the measures, which proved its effectiveness of tasks that need an exact match on color. Fluorescent lighting participants' had the lowest mean accuracy of 78.1% (±6.1), and thus for the participants, this lighting likely hindered their ability to match shades without high accuracy. This divergence of results presents a major difficulty that fluorescent lighting presents for obtaining consistent color evaluations. The LED lighting condition produced a mid range mean accuracy of 82.7% (SD ±5.9) and was less likely to fluctuate than the fluorescent lighting, but not as accurate as natural daylight. The calculated p-value of the performance varied between different lighting conditions was lower than 0.05, meaning that there was a significant difference in performance, with emphasizing that natural daylight is effective and fluorescent lighting may be problematic in the tasks requiring color differentiation. These results imply that decisions to preferred lighting conditions are crucial to the process of shade matching particularly in visual sectors such as dentistry.

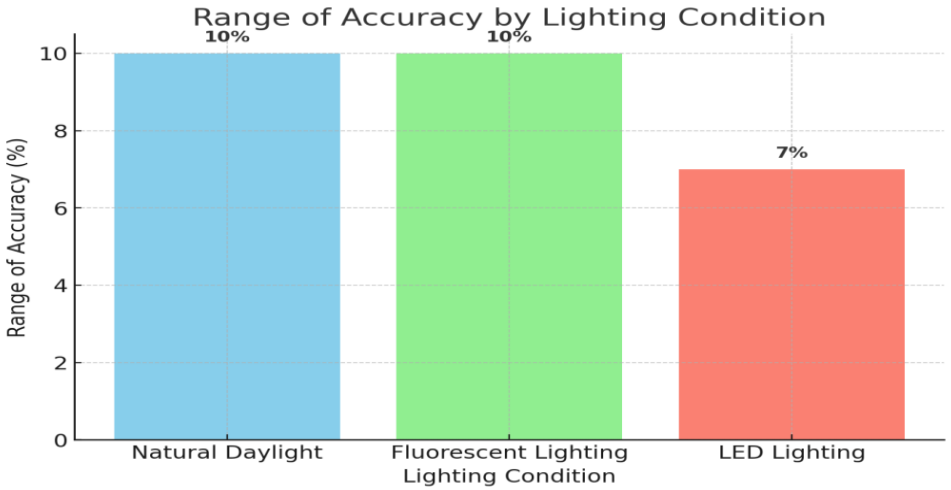

Figure 1: Range of accuracy by lighting condition

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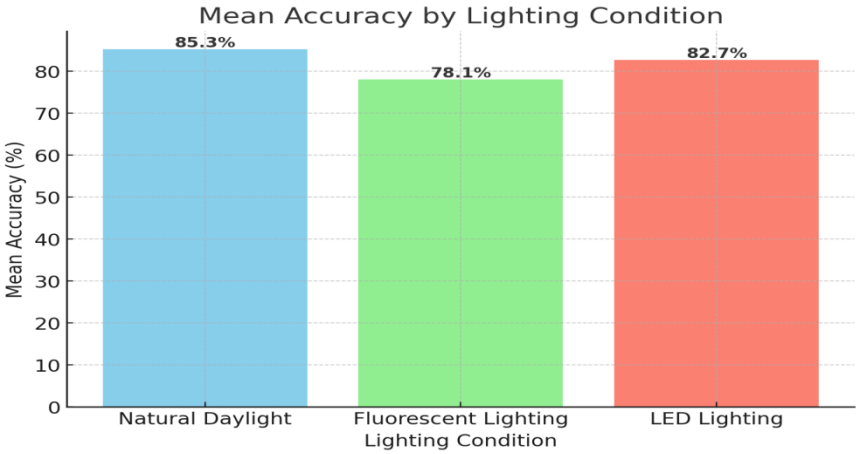

Figure 2: Mean accuracy by lighting condition

Table -1: Sample Characteristics

Characteristic	Count
Total Participants	138
Lighting Condition - Natural Daylight	46
Lighting Condition - Fluorescent	46
Lighting Condition - LED	46

Table-2: Mean Accuracy by Lighting Condition

Lighting Condition	Mean Accuracy (%)	Standard Deviation (SD)
Natural Daylight	85.3	5.4
Fluorescent Lighting	78.1	6.1
LED Lighting	82.7	5.9

Table -3: p-values for Statistical Significance

Comparison	p-value
Natural Daylight vs Fluorescent	<0.05
Natural Daylight vs LED	<0.05
Fluorescent vs LED	<0.05

Table-4: Variability and Consistency of Shade Matching Accuracy

Lighting Condition	Highest Accuracy	Lowest Accuracy	Range
Natural Daylight	90	80	10
Fluorescent Lighting	83	73	10
LED Lighting	86	79	7

Discussion

The research outcomes of the present study show that lighting condition plays a crucial role in the visual shade matching aptitude of undergraduate dental students; natural light condition renders the best for the purpose as compared to LED and Fluorescent light condition faculties. These outcomes corroborates with the earlier studies as well, where this study has also shown the improved shade matching under Natural Daylight rather than artificial light (13). The results of the current study are in consonancy with Park et al. (2018) where natural daylight was observed to yield the highest rating and precision in shade matching compared to the other lighting types (14). This the authors said was due to increased light stimulus coming from natural daylight which is closer in wavelengths range to that which human eye naturally discerns. These results agree with our study where the students' evacuation speeds were higher for daylight and achieved a 85.3% accuracy followed by the LED lighting at 82.7 % accuracy and fluorescent lighting at 78.1%. The observed performance under fluorescent lighting was the poorest of all lighting conditions in this study, in an observation that is quite consistent with the literature reviewed by Reis et al. (2019), who found that even though fluorescent lighting has been widely used in educational facilities due to its energy efficiency, its spectrums and CRI values are usually limited (15). Participants found more difficulty in distinguishing between similar shades especially if they were illuminated by the fluorescent lights, this ties with the lowered precision and the great standard deviation we recorded. Fluorescent

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lighting whether warm or cool always looks yellowish or greenish which distorts the view of the tooth color and therefore will not give accurate match (16). This is especially so for dental clinics that are still using room lights with fluorescence as their main source of illumination. Rising use of LEDs in dental practices has raised questions regarding its suitability to Dental Shade A(units). Thus, high efficiency and a longer lifespan of LED lights also suggest higher CRI values compared with the CRI of fluorescent lighting (17). Some researchers have indicated that low energy LED lighting is suitable for shade matching tasks in replacement of daylight. For instance, Lee et al., (2020), established that LED lighting made a similar accuracy to that of natural light in facilitated premises (18). Our results support this, with LED lighting providing a higher level of accuracy compared to fluorescent lighting, while not achieving the same results as those obtained under natural light. There is one potential explication for the slight difference: the LED lights in different brands and models may not always create the light of the same quality as the daylight as it is advertised (19). Remarkably, this work also showed that participants took more time to do shade matching under Fluorescent compared to Daylight and LED lighting conditions. This was in concord with Kim et al., 2017 who noted that, time taken under the artificial, particularly fluorescent, lighting was longer for shade matching tasks because of difference in the shades (20). Considering the fact that students spent more time under the fluorescent lighting they were likely to doubt their options due to the off-color representation. The same can be said about the comparison of these results with those, obtained in prior research, as more and more authors point towards the necessity of enhancing the lighting in dental education and clinical practice. Some of the recent works have underlined the need to use light sources with high CRI to guarantee better visual effects while shade matching with daylight or advanced LED systems (21, 22). In particular, Alghazali et al., 2021 recommended that more investigations should be conducted in order to design artificial light sources, which regarding accuracy are similar to natural day light for achieving more similar results in different clinics and educational facilities (23). Our results support this suggestion as natural light, though desirable, can be limited in clinical environments. Altogether, it would be possible to consider that the current work has certain educational significance and sheds light on how different lighting conditions may affect the accuracy of shade matching among the undergraduate students. That's why, the data of presented studies can be summarized and contribute to the following main conclusions The regular findings of different investigations highlighted the need of dental educators and clinicians to pay attention to the light conditions under which students are trained and clinicians provide shade matching tasks. Challenges for the next investigations include the continuation of the analysis of the technological development of LED lighting to minimize the difference between artificial lighting and daylight (24, 25).

Conclusion

The results of this study shown that the most accurate light condition for accurate visual shade matching among the examined undergraduate dental students is the natural daylight condition and then followed by the LED condition; the lowest accuracy was established in condition fluorescent light. These results imply that the choice of proper lights facilitates educational and clinical achievements, particularly in dental shade matching.

A limitation of this study is that the subjects comprised only undergraduate students and relatively junior clinicians, and thus the results may not be generalizable to highly experienced clinicians. However, the study was performed under experimental conditions and this may limit generalization of the studied results to clinical settings.

The generalization of these results implies that future research should compare such relatively sophisticated LED lighting system with natural daylight. Furthermore, research could target participants with more years of experience as dentists to check for consistency with the results as a way of enhancing clinical shade matching for every individual undertaking the practice at different levels of expertise.

Declarations

Data Availability statement

All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate.

Approved by the department Concerned. (IRBEC-TCPKP-023443/23)

Consent for publication

Approved

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Conflict of interest

The authors declared an absence of conflict of interest.

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References

1. Kallio-Pulkkinen S. Effect of display type and room illuminance in viewing digital dental radiography: display performance in panoramic and intraoral radiography. 2015.
2. Carvalho LF, Alves LMM, Bergamo ET, Benalcazar Jalkh EB, Campos TMB, Zahoui A, et al. Influence of abrasive dentifrices on polymeric reconstructive material properties after simulated toothbrushing. Biomaterial Investigations in Dentistry. 2023;10(1):2268670.
3. Cammaroto G, Gobbi R, Meccariello G, Iannella G, Gulotta G, Visconti IC, et al. PROPOFOL AND DRUG-

INDUCED SLEEP ENDOSCOPY. ADVANCES IN HEALTH AND DISEASE.129.
4. Kamber R, Papageorgiou SN, Eliades T. Does orthodontic treatment have a permanent effect on tooth color?: A systematic review and meta-analysis. Journal of orofacial orthopedics= Fortschritte der Kieferorthopädie. 2018;79(2):73-82.
5. Abd Alraheam I. Effect of Fatiguing and Thermocycling on the Mechanical and Optical Properties of Different Generations of Zirconia: The University of North Carolina at Chapel Hill; 2018.
6. Bordenave JMG. Zirconia Implants vs Titanium Implants. 2021.
7. Salehi A, He M, Hampé-Kautz V, Etienne O. Digital evaluation of dental bleaching using a new methodology: an in vivo study. International Journal of Esthetic Dentistry. 2022;17(4).
8. Kantola R. Use Of Fiber-Reinforced Composite Framework And Thermochromic Pigment In Facial Prostheses. Turun Yliopisto University Of Turku Turku. 2014.
9. Alqutaibi AY, Baik A, Almuzaini SA, Farghal AE, Alnazzawi AA, Borzangy S, et al. Polymeric denture base materials: a review. Polymers. 2023;15(15):3258.
10. Jones CL, Gibson BJ. CULTURES OF ORAL HEALTH.
11. Ther JH. 386 Clinical Reasoning and Treatment Guidelines for Common Diagnosis of the Upper Extremity PART 2. Cooper's Fundamentals of Hand Therapy: Clinical Reasoning and Treatment Guidelines for Common Diagnoses of the Upper Extremity. 2019:385.
12. Cornelius Coli C, Rizka Eka Prasetya R, Gadis Meinar Sari G, Purwo Sri Rejeki P. Effect of Moderate-Intensity Acute Physical Activity on Decreasing Cortisol Levels in Obese Female. Indian Journal of Forensic Medicine & Toxicology.15(3).
13. Coles-Brennan C, Sulley A, Young G. Management of digital eye strain. Clinical and experimental Optometry. 2019;102(1):18-29.
14. Cai H, Xu X, Lu X, Zhao M, Jia Q, Jiang H-B, et al. Dental materials applied to 3D and 4D printing technologies: a review. Polymers. 2023;15(10):2405.
15. Marques JV, Carlos NR, Turssi CP, França FMG, Junior WFV, Basting RT. Effectiveness of changing the color of darker teeth is potentiated by association with violet LED light. Photodiagnosis and Photodynamic Therapy. 2023;44:103794.
16. Korolj A. Engineering the Fractal Properties of Podocytes: University of Toronto (Canada); 2022.
17. Hannesson Á. Randomized Clinical Trial Comparing Preheated and Room Temperature Class II Composite Resin Restorations 2023.
18. Zafar MS. Prosthodontic applications of polymethyl methacrylate (PMMA): An update. Polymers. 2020;12(10):2299.
19. Saad A. Biomimetic Implants for Enhancing Implant-Epithelial Sealing: McGill University (Canada); 2020.
20. Zafar MS, Amin F, Fareed MA, Ghabbani H, Riaz S, Khurshid Z, et al. Biomimetic aspects of restorative dentistry biomaterials. Biomimetics. 2020;5(3):34.
21. Prause E, Hannak WB, Nicic R, Jakstat HA, Böning K, Klinke T. Visual Versus Digital Color Determination of 3D-Printed Teeth as an Exercise in Dental Students' Education. Dentistry Journal. 2024;12(2):24.
22. Ahmad I. Shade Evaluation for Porcelain Laminate Veneers (PLV). Esthetic Oral Rehabilitation with Veneers: A Guide to Treatment Preparation and Clinical Concepts. 2020:121-56.
23. Hardan L, Bourgi R, Cuevas-Suarez CE, Lukomska-Szymanska M, Monjaras-Avila AJ, Zarow M, et al. Novel trends in dental color match using different shade selection methods: a systematic review and meta-analysis. Materials. 2022;15(2):468.
24. Orhan AI, Bezgin T, Orhan K. Digital Dentistry Applications in Pediatric Dentistry. Digital Dentistry: An Overview and Future Prospects: Springer; 2024. p. 199-220.
25. Rekow ED. Digital dentistry: The new state of the art—Is it disruptive or destructive? Dental Materials. 2020;36(1):9-24.

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