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ORIGINAL ARTICLE

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Evaluation of visual perception towards color selection of teeth from different populations by employing color scale, white light and different background contrasts

Avaliação da percepção visual na seleção de cor dos dentes em diferentes populações, empregando escala de cor, luz branca e contraste simultâneo de fundos.

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ABSTRACT

Objective: To evaluate the visual perception of dentistry professors, technicians and undergraduates on tooth color selection through varying the background contrast and tooth translucency. **Material & Methods:** Fifteen artificial teeth of different colors and translucencies were used and divided into three groups and placed onto cardboards in the following colors: white, red and black. Blindly, the observers (professors (n = 30), technicians (n = 30) and undergraduates (n = 30), selected the artificial tooth color that they judged compatible with VITA scale, when positioned onto the three background colors, at constant illumination through white artificial light. The obtained data were statistically analyzed by Kruskal-Wallis test. **Results:** There were no statistically significant differences among the studied populations in tooth color selection, regardless of the background colors, with all observers exhibiting a high number of errors. There were statistically significant differences in the number of matching answers among the studied teeth, with those exhibiting different translucencies showing the highest error rate (D1= 2 right answers; D4 = 0 right answers). **Conclusion:** Professional expertise was not decisive in tooth color selection; the number of matching answers of the three populations varied according to the background used; the most translucent teeth with different resin layers exhibited the smallest number of matching answers and the observers' visual acuity differed and it should be effectively trained to achieve success in tooth color selection of prostheses and restorations.

KEYWORDS

Color scales; Artificial teeth; Professional expertise; Spectrophotometers.

RESUMO

Objetivo: Avaliar a percepção visual na seleção de cor de dentes por professores de odontologia, técnicos de laboratório e alunos da graduação com contraste simultâneo de fundo. **Material e Métodos:** Foram utilizados 15 dentes de estoque de diferentes cores e translucidez, divididos em três grupos e posicionados em fundos de papel cartão nas cores: branco, vermelho e preto. Os observadores professores (n = 30), técnicos de laboratório (n = 30) e alunos (n = 30), selecionavam a cor dos dentes de estoque de diferentes cores, posicionados nas três cores de fundo, sempre com iluminação de luz artificial branca e comparavam com dentes da escala de cores. Após obtenção dos dados estes foram analisados pelo teste estatístico de Kruskal-Wallis. **Resultados:** os resultados mostraram que não existem diferenças estatisticamente significantes entre as populações estudadas, quando da seleção da cor dos dentes, independentemente das cores dos fundos e que o número de acertos foi muito pequeno, necessitando de melhor aprimoramento dos profissionais e alunos de graduação. **Conclusão:** Não houve diferença nos valores de acerto dos professores, alunos e técnicos de laboratório; a distribuição de acertos nos três diferentes fundos foi semelhante para os observadores; a porcentagem de erros entre os observadores foi muito elevada; a maior parte dos acertos diferiu conforme o dente avaliado, devido à maior translucidez e camadas de resina existentes e há necessidade de maior treinamento dos profissionais de odontologia para seleção das cores dos dentes.

PALAVRAS-CHAVE

Escala de cor; Dente Artificial; Experiência profissional, Espectrofotômetro.

INTRODUCTION

The smile is a communication route for the human being, transmits emotions and improves the facial beauty, revealing feelings and personality. The smile is considered beautiful whether the teeth show harmony, proportion, symmetry, balance and color compatible with the visual perception guidelines [1].

The color perception is an eye and brain response to the light spectrum either reflected or transmitted by an object [2,3]. Every time one observes a given object, part of the light focusing on it is reflected, and the sensitivity degree of the human eye will lead to different results. The visible light spectrum may assume different colors ranging from violet to red, in relation to the wavelengths, with all colors within the light spectrum.

The Munsell color system, created in 1961, was the most scientific method for studying the colors and corresponded to a visual/ perceptive visual model of the color. It enables the observation of the axes corresponding to the color dimensions: shade, value and chroma, which will determine the final color of a restorative procedure [4-6]. Shade is the dimension regarding to the color name: red, yellow, blue, or green. Value is the quality that one distinguishes from a light or dark color, revealing the amount of white or black in the shade; and Chroma is the dimension describing the amount of pigment in the shade [7].

The human tooth is polychromatic in distributing the color and its structure has layers determining different reflections due to different planes and depths [5,6]. The observation of a more or less intense shade and the distinction of lighter or darker colors are characteristics that depend on the visual acuity of the dental professionals. To achieve a good clinical outcome, the dentist must be trained to choose the restorative color more similar to that of the patient's other teeth.

The translucency is of great importance to define the exact tooth color and it should be obtained after the definition of the tooth's degree of saturation, that is, its chroma [8]. Thus, color scales that allow evaluating the three color dimensions should be preferred.

Tooth color selection is a complex procedure influenced by the illumination type, difficult communication between the dentist and the technician, and background color. These factors can result in clinical failures and patients' dissatisfaction [6,9].

The color scales available in dental market have shown some limitations due to the non-standardization among the manufacturers and the differences in the observers' perception [6]. This variation, in addition to other events such as the influence of the background color on the perception of the colors of a given object, can be demonstrated when the teeth from the color scale are analyzed by varying the background color or considering the black background of the oral cavity or the patient's skin tone [5], making even more difficult the proper color choice by dental professionals.

Studies have shown that patients' expectations are frustrated most times at the prosthesis delivery, due to either real factors (technique error) or the imagination of a different result [10].

Bauer et al., conducted a study to test the hypothesis whether the patients' attitudes towards their body would affect their own tooth color selection in comparison with the color selected by the dental professional [11]. They concluded that the body image resulted in poor self-perception of their oral image, so that the patients perceived their teeth as lighter than they really were, influencing in their clinical satisfaction of the prosthesis delivery.

Based on the aforementioned difficulties, the aim of this study was to test the hypothesis that the dentists, undergraduates, and technicians have difficulties in assimilating and choosing properly the tooth color during prosthetic and restorative procedures, and that the dentists' expertise favors the proper tooth

color compared with that performed by the other populations.

MATERIAL & METHODS

Thirty dentistry professors, 30 senior undergraduates from the Dentistry School of the Institute of Science and Technology of São José dos Campos-UNESP and 30 dental technicians were blindly selected for this study, totalizing 90 observers. All participants were not previously trained and responded the research based on their previous knowledge. The group comprising the dentistry professors was not homogenous, so that it was composed by dentists with different specialties.

Five artificial teeth (central incisors) made from Trilux resin (Vipi produtos odontológicos, Pirassununga-São Paulo, Brazil), containing different colors were employed. The teeth were numbered from 1 to 5, preceded by the letter D. The artificial tooth colors were determined through spectrophotometer of clinical use (Vita EasyShade Compact, Vita Zahnfabrik, Bad Sackingen, Germany) and compared with VITA scale. The teeth showed increasing degrees of difficulty, defined in function of their translucence, opacity and saturation (Chart 1). For color selection, the teeth were placed onto backgrounds from white, red and black cardboard.

The observers performed the color selection based on the comparison with VITA color scale (Vitapan Classical), by electing the color of the scale similar to the color of each artificial tooth (D1 to D5). The observers carried out a total of 15 evaluations each one, comprising five on red, five on white and five on black backgrounds, under constant illumination of artificial white light, commonly employed in dental offices. The observers were not allowed to move the artificial teeth. Between each one of the observations of a same tooth, the participants were allowed to rest for 60 s so that, the eyestrain did not influence the results. Figure 1 displays the design of the groups.

Chart 1 - Colors selected by considering the similarity between VITA scale and Trilux artificial teeth

Groups	VITA scale color	Trilux tooth color
D1	A1	1A
D2	A2	2A or 1C
D3	A4	1D
D4	A3,5	2B or 1D
D5	B3	4B

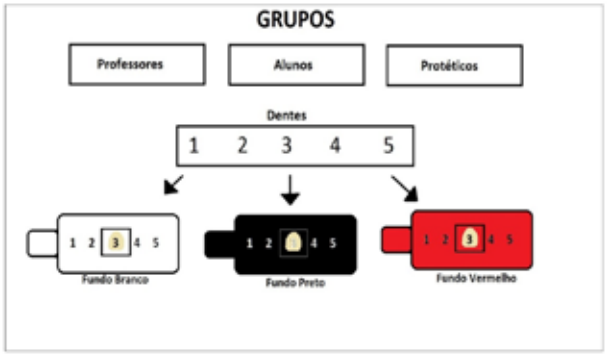

Figure 1 - Group design
GROUPS
Professors Undergraduates Technicians
Teeth
White background Black background Red background

All observers received a sheet with fifteen lines (five lines per tooth), where they recorded the color they had considered similar to the VITA scale they had. Next, after 5 to 7 min of eyestrain, the observers evaluated the next tooth, maintaining the same sequence of artificial teeth and backgrounds.

The 90 observers carried out 1,350 assessments and the obtained data were statistically analyzed by Kruskal-Wallis test.

RESULTS

To the best comprehension of the obtained results, the statistical analysis was divided into three parts:

Part 1. Evaluation of the professional expertise: professors, undergraduates and technicians.

The data obtained regarding to the evaluation of the professional expertise, regardless of the background type, are seen in Table 1.

The descriptive statistics of the aforementioned data is presented in Table 2.

The distribution of values was the same among the populations, regardless of the background type, according to Kruskal-Wallis test (kw = 0.967; df = 3 - 1 = 2; p-value = 0.616 > 0.05).

Table 1 - Absolute (n) and relative* number of matching answers (%), obtained by Professors (P), Undergraduates (U) and Technicians (T) of 15 evaluated teeth

P (n)	P (%)	U (n)	U (%)	T (n)	T (%)
16	53.33	22	73.33	18	60.00
0	0.00	0	0.00	0	0.00
9	30.00	4	13.33	5	16.67
0	0.00	0	0.00	0	0.00
7	23.33	3	10.00	1	3.33
12	40.00	11	36.67	24	80.00
0	0.00	0	0.00	1	3.33
0	0.00	2	6.67	1	3.33
0	0.00	0	0.00	0	0.00
1	3.33	1	3.33	4	13.33
15	50.00	12	40.00	18	60.00
0	0.00	0	0.00	0	0.00
0	0.00	0	0.00	1	3.33
0	0.00	0	0.00	0	0.00
1	3.33	0	0.00	6	20.00

**the matching answer ratio for each tooth was obtained by dividing per 30 (number of observers).*

Part 2. Background evaluation: white, black and red.

The descriptive statistics of data obtained in the evaluation of the three background types, regardless of the population expertise, is displayed in Table 3.

The distribution of values was the same among the background types, regardless of the population expertise, according to Kruskal-Wallis test (kw = 1.385; df = 3 - 1 = 2; p-value = 0.500 > 0.05).

Part 3. General evaluation of the number of matching answers.

The data obtained regarding to the number of matching answers in each of the five tooth types, according to the background and population type is seen in Chart 2, below.

Chart 2 - Number of matching answers in each one of the five teeth and calculation of the matching answer rate, according to the population (P = professor, U = undergraduate, T = technicians) and background type

Group	Background	D1	D2	D3	D4	D5	Sum of matching answers	Rate of matching answers
P	White	16	0	9	0	7	32	1.00
U	Black	24	1	1	0	4	30	1.00
T	White	22	0	4	0	3	29	0.97
U	Red	18	1	1	0	6	26	0.87
U	White	18	0	5	0	1	24	0.80
P	Red	15	0	0	0	1	16	0.53
T	Black	11	0	2	0	1	14	0.47
P	Black	12	0	0	0	1	13	0.43
T	Red	12	0	0	0	0	12	0.40

Table 2 - Measure of central tendency and dispersion of matching answer ration, according to the population type

Groups	n	Q1: 25th percentile	Q2: Median	Q3: 75th percentile	mean	SD
Professors	15	0	0	30.00	13.56	20.10
Undergraduates	15	0	0	13.33	12.22	21.41
Technicians	15	0	3.33	20.00	17.56	26.56

Table 3 - Measure of central tendency and of matching answer ratio, according to the background type

Background	n	Q1: 25th percentile	Q2: Median	Q3: 75th percentile	mean	SD
White	15	0	10.00	30.00	18.89	24.61
Black	15	0	3.33	13.33	12.67	22.68
Red	15	0	0.00	20.00	11.78	20.77

It could be verified that: (i) most part of the matching answers occurred in tooth D1; (II) teeth D2 and D4 (with translucency differences) showed a greater difficulty to match the responses, regardless of the background color and population expertise; (III) the professor group, analyzing on white background, had the highest matching answer ratio; (IV) the technicians group, analyzing on red background, had the smallest matching answer ratio; (V) the undergraduate group showed matching answer ratio ranging between 0.80 (white background) and 1.00 (black background).

DISCUSSION

Color selection of either restorations or prostheses is a difficult step and depends on visual acuity and training of professionals in details of shape and color, which are different from one person to another, compromising the esthetic outcome of the treatments that although may meet the morphology and physiology of the dental system do not reach a complete and satisfactory result. Incorrect color selection leads to dissatisfaction of both the dentists and patients, and the first need to improve their technical skills to achieve a more favorable result [6].

The difficulties occur due to the complexity in color tooth observation, since many aspects have to be considered, such as those from morphologic, optical and biological point of view. Currently, most of Dentistry Schools do not give proper attention to this type of training; or provide it superficially, little contributing for the knowledge of the undergraduates, [8,12], making the restorative practice difficult. By agreeing with our results, since the number of errors was statistically greater than that of correct answers, Freitas et al 2008 also concluded that there is the need of technical improvement in tooth color selection by dentists and undergraduates [13].

Sproull (2001) suggests that the dentist must understand the definitions and relative importance of value, chroma and shade to achieve the capacity of selecting correctly the tooth color in restorative procedures; and that the dentists must be well prepared in Dentistry Schools to choose tooth color correctly.

The color selection of ceramics is more difficult than that of resin composites because of the great variety in the colors available for this material. The substrate color, the ceramics thickness, the limitations of the color scales, the ceramics composition and illumination type have been important factors determining the restoration success (6,9). Also, the implant abutments colors, luting agents and surface texture affect the optical properties of ceramics [14-17].

Tooth color selection of resin composite is easier due to the technological advancement of this material of easy insertion with a variety of colors and effects that enables matching its translucency and opacity, sculpture and reproduction of tooth morphology with those of the natural teeth, just through training in scientific and artistic guidelines to reach esthetic success [18]. Additionally, resin composite allow fast adjustments whether the color is incorrect, unlikely ceramics which are constructed in laboratory, making the correction difficult.

In addition to real facts that may contribute with restoration failures, other facts may act together with psychological factors [10]. The patient must have a very high expectation in relation to the final esthetic and "imagined" tooth color outcome, resulting in frustrations and making the dental profession/ patient relationship difficult. Bauer et al 2012 tested the hypothesis that the attitude of patients towards their body could affect tooth color selection [11]. These authors concluded that the body image results in a poor self-perception of oral image and these patients perceived their teeth lighter than the selection performed by the dentist, mostly in females.

In this present study, we observed the perception of three populations (Professors - P; Undergraduates- U and Technicians – T),

towards the tooth color selection and verified that the distribution of matching answers was equal among the three groups, regardless of the background type. Therefore, expertise was not decisive, although the technicians exhibited a greater number of matching answers without statistical significance (T-17, 56; P-13, 56 and A-12, 22). The similar number of errors was also found by Freitas et al, in 2008, but not by the study of Della Bona et al. 2009, who observed a higher color perception by dentists (42%) compared with undergraduates (12%) [13,19]. Notwithstanding, these authors also verified a relatively high number of errors, agreeing with this present study and that of Freitas et al 2008 [13].

Aiming to assess the influence of the background color, the artificial teeth were placed onto white, black and red cardboards and they were analyzed one at a time. The matching answer number was the same among the three background types (black, red and white), regardless of the population expertise. The white background exhibited the greatest number of matching answers by dentists (white - 18.89; red - 12.67 and black - 11.78), but without statistical differences and with a large number of errors among all observers. In the technician group, the red background reached the smallest matching answer ratio.

These results suggest that the visual acuity of the observers is very different, making difficult to match tooth color. Preston and Bergen (1980) verified that the color perception differs among groups of different age and gender, and females show a more accurate visual acuity than males [20].

The illumination or background, in this present study, was one of the factors contributing for the correct or wrong final color [9]. Based on these findings, one can assume that the visual perception undergoes variations depending on the illumination. Local illumination is other factor interfering in color selection [21]. In this present study, white artificial light was used, despite of the fact that this is not ideal, but is that closest to the natural light spectrum and considered as the most correct one [6]. Notwithstanding, because the teeth were onto colored backgrounds, mainly red and black, this could make difficult the visual perception of the observers, resulting in a high number of matching answers onto a white background..

There are different visual acuity types, and each one, depending on the specific task or detail, almost always involves the difference in the brightness between an object or part of an object and its background. However, visual acuity refers to the capacity of the visual system to discriminate fine details of the objects. The detection and recognition of a pattern occur from the image projected into the retina, codified and processed through the connections among the nervous structures comprising the visual system [22]. The brain can also be misled regarding to color perception due to metamerism, where the colors can be similar depending on the illumination. Thus, the observer cannot repeat the color selection of a specific tooth at different days, resulting in different colors [6].

In the general evaluation of the number of matching answers, most differences occurred according to the tooth evaluated, that is, those presenting different levels of translucency and composition of resin layers, mimicking the enamel and dentin of natural teeth, showed the most difficulty in perception. Thus, D2 and D4 errors were greater, regardless of the background color and population expertise.

Tooth color selection is a complex task. However, if technical criteria are carefully observed, one can reach acceptable outcomes. Technical improvement of dental professionals is an important path to be followed, so that matching answers can be more effectively obtained.

CONCLUSION

- The population expertise was not decisive in tooth color selection;
- The number of matching answers in the tree populations varied according to the background;
- Less translucent teeth and teeth with different resin layers exhibited most difficult in obtaining matching answers;

- The visual acuity of the observers needs to be more effectively trained to obtain success in tooth color selection for prostheses and restorations.

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