

## Assessment of perceptibility and acceptability of color variations between matched teeth among trainee dentist and lay person

A. S. Ramesh, Aruna Sharma<sup>1</sup>, K. Rijesh, R. Prakash<sup>2</sup>, Lakshmi Devi, Edilbert Raja

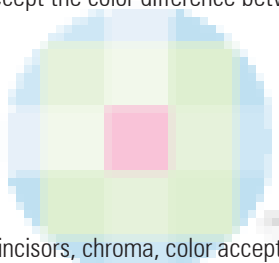
Department of  
Prosthodontics,  
Adhiparasakthi Dental  
College and Hospital,  
Melmaruvathur, <sup>2</sup>Anil  
Neerukonda Institute  
of Dental Sciences,  
Visakhapatnam,  
Andhra Pradesh,  
<sup>1</sup>Department of  
Pedodontics, Tagore  
Dental College, Tamil  
Nadu, India

**Address for correspondence:**

Dr. A. S. Ramesh,  
E-mail: raassi@yahoo.com

### ABSTRACT

**Aim:** The aim of this study was to find the difference in perceptibility and acceptability of changes done to various color coordinates of matched teeth, between trainee dental surgeons, and lay person. **Materials and Methods:** A photograph with a set of matched central incisor teeth was selected. In one of the central incisors, the color coordinates (hue, value, and chroma) were altered to a preset value. These pictures were presented to trainee dental surgeons and lay person and their level of perception of color change and acceptance of color change was registered and compared. **Results:** It was found that trainee dental surgeons fared better in perceiving the color change and accepted less of the color changed specimens. The dimension of color that was more discerned both by lay person and trainee dental surgeons was value, hue, and last chroma. **Conclusion:** When compared to a lay person, dental surgeons are more acute in perceiving color changes and do not accept the color difference between teeth to a higher degree.



**KEY WORDS:** Central incisors, chroma, color acceptability, color perceptibility, dimensions of color, esthetics and sensory threshold, hue, trainee dental surgeons, value

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Visual shade matching seems to be a skill acquired through clinical experience. This has been studied and stated by Verriest *et al.*<sup>[1]</sup> and Capa *et al.*<sup>[2]</sup> With the increasing popularity of esthetic restoration accurate shade matching has become essential to an optimal dental restoration and successful clinical practice. Image of self, very strongly influences patients in their decision to obtain treatment while 50% of remakes for esthetic restorations are result of failure to match shade accurately leading to unnecessary additional patient visit, dentist anguish, staff frustration, and lab remake fees. Correct shade choice is limited by knowledge of color science, clinical experience, time constraints, and patient cooperation. Visual color selection is dependent on many factors and variation in any of the can lead

to an altered color perception. Though it is contended that the female gender can perceive color better, studies by Milagres show that male discern color better.<sup>[3]</sup>

Color has been described as a three-dimensional phenomenon, consisting of hue (color), value (brightness), and chroma (saturation). No single tooth is of uniform color. All teeth are the aggregate of number of hues and varying shades of the same hue. Due to the subjective nature of perceptual shade matching, the skill to match shades is acquired through knowledge of basic color principles and clinical experience thus making a lay person not credible as sole decision makers in shade selection.

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Studies by Al-Wahadni *et al.*, have shown that Patients are more satisfied with shade matching rather than the prosthodontists.<sup>[4]</sup> However, can this be generalized over the whole population and if so, how early is this ability acquired. Hence, a study was proposed to check for the effect at the grass root level. Hence, trainee dental surgeons were inducted into the program. The study was designed to find out the ability of trainee dental surgeons and lay person to differentiate color difference and to find the level of variation in color acceptable to them.

The aim of the study was to assess the perceptibility and acceptability of color variations between matched teeth among trainee dentist and lay person.

## Materials and Methods

On approval from Ethical Committee of Adhiparasakthi Dental College and Hospital, the study was started. Photographs of five different subjects with matched teeth were made using the digital single-lens reflex camera under high resolution. Using Adobe Photoshop, version 7 (Adobe Systems Inc., San Jose, CA, USA) color of one of the selected central incisor of one of the photographs (the other four were discarded) was modified in different the different dimensions of color that is, hue, value, chroma to predetermined levels ( $\pm 2\%$ ,  $\pm 4\%$ ,  $\pm 6\%$ ,  $\pm 8\%$ , and  $\pm 10\%$ ). The contralateral central incisor was not modified and served as a control.

Hard copies of modified teeth were shown to trainee dental surgeons and lay person. Inclusion criteria being trainee dental surgeons of the selected institution and lay persons were people who visited the Department of Prosthodontics at Adhiparasakthi Dental College and Hospital. Person with a known history of color blindness, person above the age of 50 years, and person who were not willing were excluded from the study. After exclusion 100 CRRI and 100 lay persons participated in the study. Condition of each viewing session was standardized as much as possible. The task was performed in a spacious room with multiple windows to avoid fatigue and allow for optimal lighting conditions. Subjects viewed the photographs at a 30 cm distance.

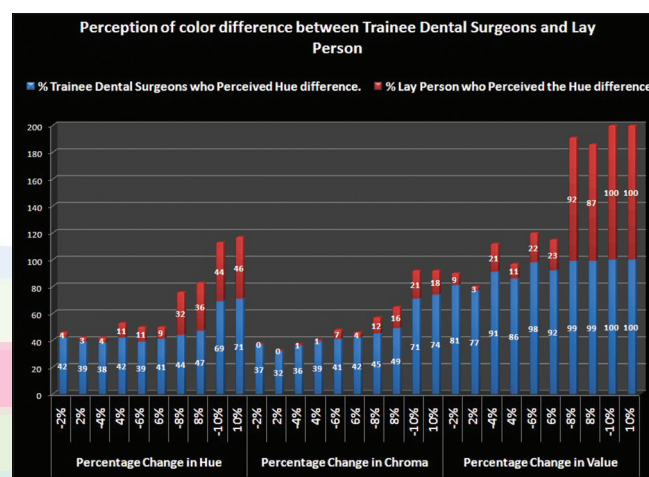
The study was a multicentric double-blinded randomized control trial. The study is multicentric since it was conducted in five different centers, double-blinded since both the operator and assessors were not aware of the changes done to the photos and the key was kept aside till the end of the survey, randomized since the CRRI and lay person were selected at random with only the inclusion and exclusion criteria as guide, control trial as un-modified contralateral central incisor served as control. The responses of CRRI and lay person were collected on a survey form and were recorded for statistical analysis.

## Results

The result is as follows.

Table 1 and Figure 1 on values of Perceptibility of Change in Hue, Value and Chroma shows that lay person were able to perceive the change in Value more than  $\pm 8\%$ , hue more than  $\pm 10\%$  and chroma more than  $\pm 10\%$  and the trainee dental surgeons was able to perceive changes in value more than  $\pm 2\%$ , hue more than  $\pm 8\%$  and chroma more than  $\pm 8\%$ . This denotes that the trainee dental surgeons were able to perceive changes in value and chroma much more significantly than the Lay person.

Table 2 and Figure 2 on values of acceptability of change in Hue, value and chroma shows that as far as acceptance of color change is concerned, trainee dental surgeons were more critical in acceptance of changes as they did not accept changes in Value less than  $\pm 4\%$ , Hue less  $\pm 8\%$  than and chroma less than  $\pm 10\%$ . Comparatively lay person did not accept color changes value less than  $\pm 6\%$ , Hue less  $\pm 10\%$  than and Chroma less than  $\pm 10\%$ .

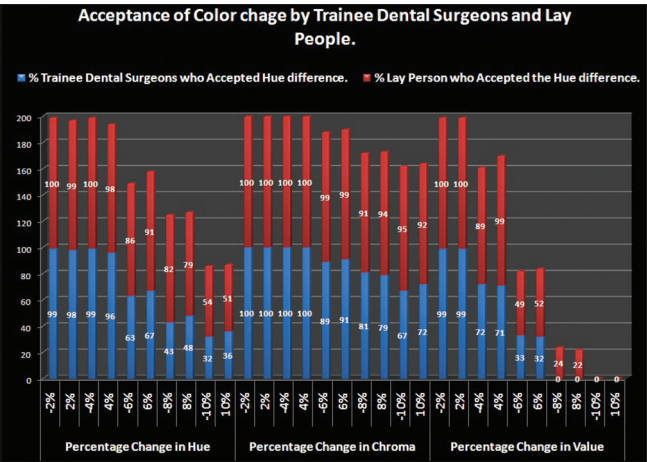


**Figure 1:** Comparison of the perceptibility of various changes in dimensions of color by dental color rendering index and lay person

**Table 1:** Dental CRI were able to perceive Hue, Value and Chroma better than Lay person

	Percentage Change in Hue									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who perceived Hue difference	42	39	38	42	39	41	44	47	69	71
% Lay person who perceived the Hue difference	4	3	4	11	11	9	32	36	44	46
	Percentage change in Chroma									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who perceived the Chroma difference	37	32	36	39	41	42	45	49	71	74
% Lay person who perceived the Chroma difference	0	0	1	1	7	4	12	16	21	18
	Percentage change in Value									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who perceived the Value difference	81	77	91	86	98	92	99	99	100	100
% Lay person who perceived the Value difference	9	3	21	11	22	23	92	87	100	100

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**Figure 2:** Comparison of the acceptability of changes in various dimensions of color by dental surgeons and lay person

**Table 2:** Lay person accepted color though it was different to a higher degree than dental CRI

	Percentage change in Hue									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who accepted Hue difference	99	98	99	96	63	67	43	48	32	36
% Lay person who accepted the Hue difference	100	99	100	98	86	91	82	79	54	51
	Percentage change in Chroma									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who accepted the Chroma difference	100	100	100	100	89	91	81	79	67	72
% Lay person who accepted the Chroma difference	100	100	100	100	99	99	91	94	95	92
	Percentage change in Value									
	-2	2	-4	4	-6	6	-8	8	-10	10
% Trainee dental surgeons who accepted the Value difference	99	99	72	71	33	32	0	0	0	0
% Lay person who accepted the Value difference	100	100	89	99	49	52	24	22	0	0

Discussion

“Esthetics” is a Greek word meaning “perception.” It deals with the various aspects of beauty. Beauty may be regarded in two ways: Objective and subjective. Objective beauty is based on the consideration of the object itself based on preconceived notions. Subjective beauty is a quality that is relative to the tastes of the person enjoying it.<sup>[5]</sup> When we smile, our smile could often become the target of close scrutiny by the person you are smiling at. A trained eye readily detects any asymmetrical aspect of that smile. Color of the teeth is one such aspect. Perception and acceptance of such color changes may or may not be an inherent or trained trait.

Studies of Douglas *et al.*<sup>[6]</sup> have proved that among professionals, the perception of color change was higher. Studies have also

proved that lay persons have a much higher tolerance level to variation in color. In a study by Al-Wahadni *et al.*, they found that patients were more satisfied with the color matching of their porcelain-fused-to-metal crowns more than their prosthodontists.<sup>[4]</sup> This leads us to speculate on whether the patient input is really necessary for shade selection. Moreover, no study has been conducted to know as to how and when this ability of the dental surgeon blooms.

A study by Kijima *et al.*,<sup>[7]</sup> it was noted that color discrimination was made firstly in terms of hue, secondly in terms of value, and thirdly in terms of chroma. However, they failed to discriminate as to by whom and to what degree.

It has been studied and stated by Barna *et al.*<sup>[8]</sup> “Color perception defectiveness cannot be overcome by any number of years of experience and color-defective dentists should obtain assistance when matching tooth shades”.

Hence, the question as to how and when does this ability of the dental surgeon to perceive and discern this color difference develops. Is it through years of practice after qualification or much earlier? Hence, a study was designed to test the perceptibility and acceptability of color variations between matched teeth among trainee dentist and the common man.

A picture of a person’s smile with matched central incisor was chosen. One of the central incisors was modified using Photoshop in the three dimensions of color viz. hue, value, and chroma to predetermined levels. ( $\pm 2\%$ ,  $\pm 4\%$ ,  $\pm 6\%$ ,  $\pm 8\%$ , and  $\pm 10\%$ ). These modified photographs along with the unmodified picture were given to dental trainees and lay person and were asked to find out if they could discern the color change and what color they found acceptable.

The study shows that the dental trainee was able to perceive the color differences much better than lay person to a significant degree similar to those of Capa *et al.*<sup>[2]</sup> It was also found that acceptance level of mismatched color was much lower in dental trainee than a lay person. This proves that color perception is an acquired skill that starts much earlier in a dental surgeons life and may be honed through years of experience. Dental trainees were also more stringent on their acceptance of color variation to a significant level. This may be because of setting a higher standard for oneself to overcome any failure that could arise because of color difference. Later this practice becomes a learned trait. This learning is not about simple color perception but as put forth by Kyle *et al.*, it may instead result from how adaptation alters the relative salience of the target.<sup>[9]</sup> This could also be because of perceptual grouping at a psychological level and, at the same time, outlines the mechanisms for grouping at the neurophysiological level as proposed by Pieter *et al.*<sup>[10]</sup>

Of the three-dimensions in color, both the dental surgeon and lay person were able to perceive changes in value more than hue. The least perceived change was chroma. This is consistent with the findings of Ratzmann *et al.*<sup>[11]</sup> who perceived similar results but varied from the studies of Kijima *et al.*<sup>[7]</sup> This could be due

to increase in test subjects and the inclusion of Lay person in the study group.

Though both subject groups were able to perceive color change, acceptability of color also varied greatly. Both the groups were able to accept change done to chroma and hue to a greater degree than to changes done to value in that order. This could be attributed to the color perceiving sense of the eye.

## Conclusion

With the limited results, it can be concluded that the perception of color difference seems to be a learned trait. Whether it is enhanced by experience is still a question at large. As far as acceptance of color variation is concerned, dental surgeons are stricter and hence are a better judge. But still as beauty is in the eyes of the beholder, the final onus of color selection is on the subject themselves.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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