

## **Original Research Article**

### **To assess the effect of lighting on identifying the Ischihara colour vision plates in Trichomats.**

**Aims:** The main aim of present study is to investigate the effect of luminance on identifying the Ischihara colour vision plates in normal trichomats.

**Study design:** Experimental quantitative study design.

**Place and Duration of Study:** Dr.Rishi Bhardwaj Visual Psychophysics laboratory, School of Medical sciences, University of Hyderabad-INDIA, 1-year (07/2015 to 07/07/2016).

**Methodology:**  $n=60$  participants of age group 18 to 21 years both male & female and inclusion criteria was trichomats, emmetropes with no history of ocular pathology and randomized sampling was done to study the experiment in lab setting with three different illuminations (Compact fluorescent light- CFL), Fluorescent light, LED light) with constant 400-lux is maintained for the experiment followed by colour vision assessment with Ischihara colour vision plates 38<sup>th</sup> edition (printed) version. Followed by Satisfactory and feedback of comfort was received by participants.

**Results:** The relation between lighting and colour vision plates response has no statistical significance exists ( $P=0.007$ ) males & females ( $P=0.056$ ). But the isochromatic plate identifying speed is faster (1 - 3 sec) under fluorescent lighting compare to CFL, LED Similarly the distribution of symptoms related to colour vision was very less in fluorescent lighting (10-30%) followed by CFL (10-55%). But LED lighting shown more symptomatic (30 – 75%). Satisfactory feedback from sixty participants showed that 36 participants recommended (Fluorescent=63%) lighting was good while identifying ischihara colour vision plates followed by 12 recommended (CFL=20%) and 10 participants recommended (LED=17%).

**Conclusion:** This experiment concludes that ischihara colour vision plates are a tool for red and green deficiency screening. But the luminance intensity and types of lighting play a vital role for discriminating the numerals that imbedded in isochromatic plates, fluorescent lighting showed better results and faster speed to recognize the isochromatic plates compare to CFL and LED luminance in trichomats.

**Key words:** *Luminance, Colour vision deficiency, trichomats, isochromatic plates, colour discrimination.*

### **Introduction**

The importance of Pseudo isochromatic plates used in Ischihara Colour vision test in screening colour vision is an important tool to detect CVD (colour vision deficiency). But observer is required to identify a numerical letter most usually, embedded in a background of visual pigments and differentiated from it on the basis of colour discrimination<sup>[1]</sup>. Changes in the

perception of colours can be produced by adaptation to colored luminance without changing the eye's colour-discriminating power, and without upsetting colour matches between lights of different spectral composition<sup>[2]</sup>.

Trichomats (independent channels for conveying colour information, derived from the three different types of light sensors of retina called as cone cells presence of three cone cells responsible for colour processing in retina Red, Green, Blue cone cells)<sup>[3]</sup>. When single colour light passes to retina from the peripheral areas of pupil appears of a different colour. Similarly when light reaches through centre of the pupil. It observed that two lights of different composition match when the light rays reach the retina from the centre of the pupil and may not match when they reach it from the periphery areas<sup>[4]</sup>. This paper mainly focused on how the overhead lighting influences colour vision plate's assessment in normal subjects and do luminance is showing any effect on visual pigments on the Ishihara colour vision plates.

## **Materials and Methodology**

### *Participants*

This experimental quantitative study design was performed in 60 subjects with an age group of 18 to 21 years. Both male and female participants were undergone experiment and inclusion criteria was normal Trichomats (independent processing of three colours red, green, blue) and emmetropes<sup>[5]</sup> (an spherical equivalent of 0.00 to - 0.50D) followed by no history of ocular pathology and colour blindness. A randomized sampling was done to conduct study and followed with the declaration of Hensky and by Institutional ethics committee approval at School of Medical sciences, University of Hyderabad. Written and oral consent received before participation in the experiment. No monetary award was paid to participants in this experiment.

### *Experimental setup*

To conduct this experiment in lab setting we used 3 different lights as over head illuminations CFL-15watt (compact fluorescent light), Fluorescent tube light-25 watt, LED light -8watt and constant 400-lux is maintained with the digital photometer model-(HS1010) and 1-meter distance is maintained from light source to colour vision plates followed by colour vision assessment with Ishihara colour vision test-38 edition<sup>[6]</sup>. Speed of discriminating the chromatic plates was measured using a Kadio (model KD-2004) stopwatch to record time.

### *Experimental procedure*

Before starting experiment, all the participants were instructed about task orally. Participants were asked to seat in chair with overhead illumination, and checked for luminance intensity after this a Ishihara colour vision plates-38 edition printed version (pattern recognition plates omitted) was placed at 30cm of testing distance and asked to identify the numeral in the plates and time was recorded to identify each plate and after completion of this test under each light source. A time gap of fifteen minutes is given to the subjects to overcome the light adaptation time. Same experiment had repeated under all three illuminations to check the differences under lighting sources. After completion of experiment each subject was given a feedback form with closed ended questionnaire and asked to suggest which is the better lighting source and satisfactory for colour vision.

### *Data Analysis*

All the data was stored in Microsoft excel 2003 version software followed by IBM SPSS-20 version statistical software is used to run the analysis .Normal distribution of data was checked with Shapiro-Wilk test. The variables were analyzed with repetitive measures of one way ANNOVA statistical test. And the symptoms experienced by the participants during colour vision task were calculated on distribution of percentage.

## Results

This study includes 60 participants with (50% male, 50% female).The relation between lighting and colour vision plates response has no statistical significance exists ( $P=0.007$ ) males & females ( $P=0.056$ ) as shown in **table-1**. But the isochromatic plate identifying speed is faster (1 - 3 sec) under fluorescent lighting compare to CFL, LED as shown in **table -2**.Similarly the distribution of symptoms related to colour vision was very less in fluorescent lighting (10-30%) followed by CFL (10-55%).But LED lighting shown more symptomatic (30 – 75%) as shown in the **table-3**. Satisfactory feedback from sixty participants showed that 36 participants recommended (Fluorescent=63%) lighting was good while identifying ischihara colour vision plates followed by 12 recommended (CFL=20%) and 10 participants recommended (LED=17%) as shown in the **figure-2**.

## Discussion

Even though considerable amount of research is going on around the world on colour vision but we still need to understanding about luminance effect on colour vision. We found only few studies supported or contraindicated on present study results .Although Ischihara colour vision screening test is gold standard but few disadvantages will be seen. To test colour vision although ischihara chart is common and used universally in clinics but it only gives idea about CVD in red and green deficiency, all the pseudo isochromatic plates were easy to identify the subjects for CVD <sup>[7]</sup>. (Hattem et al, 2014) study supported that paper based ischihara colour vision test showed results less accurately than computer based colour vision screening tool similarly sensitivity and specificity is (100%) in computer version of Ischihara chart<sup>[8]</sup> . Our study showed that the relation between lighting and colour vision plates response has no statistical significance exists but, colour vision assessment under different luminance showed better results in Fluorescent lighting (63%) of participants were satisfactory. Normal time required for identification of each isochromatic plate is 3 seconds<sup>[9]</sup>. But our study explained that luminance also influence the identity of isochromatic plates i.e., LED (24 participants took 4-10 seconds) followed by in CFL 17 participants and Fluorescent -12 participants for late response was noted as shown in **Table-3**. Luminance for these tests is not always specified, it should be in the range of 100 to 650 lux. For many years, the Macbeth easel lamp was the lamp of choice, but it is no longer commercially available. The Macbeth uses a 100-watt clear, incandescent bulb that is covered with a blue glass filter to achieve the right color temperature <sup>[10]</sup>. Present study we used different lighting sources and maintained a constant of 400lux intensity which showed a good results for Fluorescent lighting and followed by CFL but not LED , it is suggested that CFL or Fluorescent luminance gives better results and less symptoms for the normal trichomats compared to incandescent lighting. (Johnson D.D et, al 1992) conducted an experiment to replace the Macbeth easel lamp essentiality for screening color vision with the Ishihara test and designed a true daylight illuminator to control the accurate luminance and to achieve better results in colour vision <sup>[11]</sup> . In our experiment design we used a digital photometer to control and check the intensity of different light sources to assess the colour vision. (Kaoru Nakamura et al 2002) study suggested that new tests should be developed for accurate assessment of colour vision and also sensitivity and reproducibility for discriminating the subjects with color

vision defect had shown good results with isochromatic lines than plates <sup>[12]</sup>. However our experiment also suggested that in trichomats luminance and its type also play a role in identifying the colour vision.

## Conclusion

This study outcome emphasizes even though ischiara colour vision plates for red and green deficiency screening .but the luminance intensity and types of lighting play a vital role for discriminating the numerals in isochromatic plates, fluorescent lighting showed better results and normal speed to recognize the isochromatic plates compare to CFL and LED luminance in trichomats. So it is advised to check the type of lighting always in clinics for better and accurate results of Ischiara colour vision.

## CONSENT

All authors declare that 'written informed consent was obtained from the patient for publication of this research paper. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.

## ETHICAL APPROVAL

This research was approved by Institutional Ethical Committee, School of Medical sciences, University of Hyderabad-500046, Telangana, INDIA by giving approval and the study number is (UOH/IEC/2015/134)

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki."

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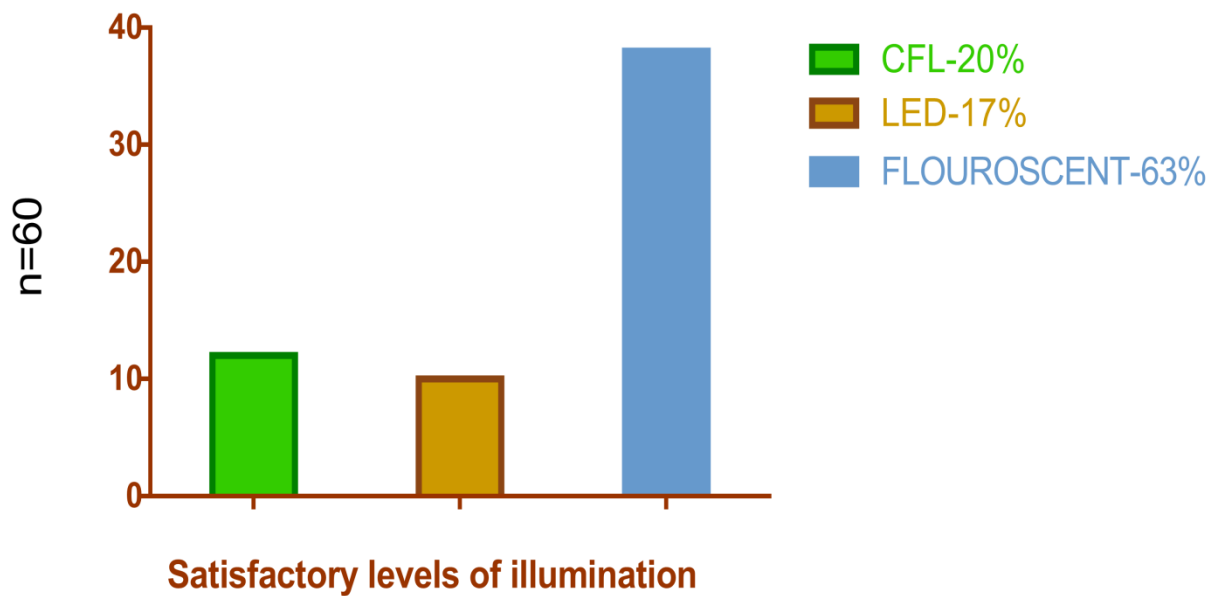
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## Abbreviations

1. CFL- Compact Fluorescent light
2. LED-light emitting diode
3. FLOU-Fluorescent light
4. CVD- Colour vision deficiency
5. Lux- units for intensity of light



**Figure-1** Experimental seating arrangement of participant for reading ischihara colour vision plates under different lighting sources.



**Figure-2** Bar graph showing the satisfactory levels of participants for colour vision comfort under different light sources (Flou=63%) followed by ( CFL=20%) and (LED=17% ) with n=60

(Colour vision)	N=60	FLOU (n=20 )	CFL (n=20 )	LED (n=20 )	One way ANNOVA analysis		
	Gender	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	df	r	p
<b>Isochromatic</b> Plates recognized  <b>Total plates = 17</b>	<b>Male</b>	16.75 $\pm$ 0.0	15.2 $\pm$ 0.48	16 $\pm$ 0.0	0.025	0.018	0.007
<b>Isochromatic</b> Plates recognized  <b>Total plates = 17</b>	<b>Female</b>	16.55 $\pm$ 0.49	15. $\pm$ 0.43	16.35 $\pm$ 0.47	0.026	0.019	0.0056

*\*p <0.005 is level of significance*

**Table-1** Friedman test showing difference between colour vision in different lighting with One way ANNOVA analysis.

Symptoms experienced	N=60	CFL (n=20)		LED(n=20)		FLOU (n=20)	
	Gender	M	F	M	F	M	F
Colour Confusion		50%	30%	75%	25%	30%	20%
Colour Discrimination		50%	40%	48%	52%	10%	10%
Colours fading		45%	55%	54%	46%	10%	10%
Colour dots Moving		20%	10%	70%	30%	0%	0%

**Table-2** Distribution of symptoms for colour vision under different lighting

<b>Types of chromatic plates in Ischihara colour vision Book</b>	<b>Time required to identify plate (seconds)</b> <i>(Normal speed =1 to 3 sec)</i>	<b>CFL</b> <b>n=20</b>	<b>LED</b> <b>n=20</b>	<b>FLOU</b> <b>n=20</b>	<b>N=60</b> <b>percentage</b>
<b>Demo plate</b> (Number=12)	1 sec to 3 seconds	20	20	20	100%
	4 sec to 6 seconds	--	--	--	--
	7 sec to 10 seconds	--	--	--	--
<b>Transformation plates</b> (8), (6), (29), (57), (5), (3).	1 sec to 3 seconds	15	11	18	74%
	4 sec to 6 seconds	3	4	1	13%
	7 sec to 10 seconds	2	5	1	13%
<b>Vanishing plates</b> (15),(74),(2),(6),(97),(45)	1 sec to 3 seconds	16	13	17	77%
	4 sec to 6 seconds	1	3	2	10%
	7 sec to 10 seconds	3	4	1	13%
<b>Hidden digit plates</b> (5), (7), (16), (73).	1 sec to 3 seconds	12	10	13	59%
	4 sec to 6 seconds	2	3	2	12%
	7 sec to 10 seconds	6	7	5	30%

**Table-3** Distribution of participants showing recognition Speed of isochromatic plates of ischihara under different lighting N=60