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Original Article

Development of computerized color vision testing as a replacement for Martin Lantern

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ABSTRACT

Background: Development and standardization of computerized color vision testing as a replacement for Martin Lantern test. Non-randomized comparative trial.

Methods: All candidates of SSB, Allahabad, reporting for SMB underwent color vision testing at the eye dept by computerized eye test and currently available tests.

Results: All candidates were subjected to Ishihara chart testing and those found to be CP III were subjected to the confirmatory test on Martin Lantern and the Software. Candidates requiring CP I standards for eligibility were tested on the same on Martin Lantern and on the new software method. On comparison between the Standard Martin Lantern and the Software, the results were consistent and comparable with 82 patients testing CP I on the Martin Lantern and 81 on the software. Of the CP III patients, 253 tested positive on the Standard lantern test as compared to 251 on the software and of the CP IV group, 147 tested positive on the Standard lantern and 149 by the software method.

Conclusion: It was found that the software replicated the existing Martin Lantern accurately and consistently. The Martin Lantern Software can be used as a replacement for existing old Lanterns which are not in production since the early 20th century.

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Introduction

Color discrimination is defined as the ability to differentiate between shades of a color or the difference between two or more colors. The factors that influence color discrimination have been described thoroughly (e.g., Kaufman, 1974; Schiff, 1980; Sekuler & Blake, 1990).

The human retina is made up of receptors called rods and cones. When only the rods, densest outside the central retina or macular area, are functioning, colors are not visibly

perceptible. Cones, densest in the central retina, provide the perception of color. Humans with normal color vision are traditionally regarded as having three cone types, supporting trichromacy, the ability to match colors with three primaries.

Color vision testing in the armed forces has been based on use of the Martin Lantern and the Ishihara charts. The Martin Lantern (Fig. 1) is available at only limited centers and is an out of production model last produced in the 1940's.

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Fig. 1 – Martin Lantern & Computerized Martin Lantern.

Color vision standards in the armed forces

- CP I – Evaluated after testing on the Martin Lantern, at a distance of 6 m (20 ft)
- CP II – Evaluated on Ishihara charts
- CP III – Evaluated on Ishihara charts, confirmatory testing on Martin Lantern at 1.5 m
- CP IV – Evaluated on Ishihara charts, confirmatory test on Martin Lantern

This project was hence started to prepare a computerized alternative to the Martin Lantern which could be used on a standalone Personal Computer (PC) just like a Martin Lantern, leading to standardization of testing procedures across all eye centers in the army.

Color vision testing has been used over the ages and has seen a gradual improvement in methods available. One of the earliest methods was to ask a person to compare color of everyday objects with that of a normal person. Dalton in 1798 gave a detailed description of his own perceptions and that of his own brother and of 20 other persons.¹ Seebeck² in 1837 used a number of test samples and asked the observer to choose and match the same with samples. Variations of this method were developed by various researchers, namely, Holmgren³ in 1877, who used wool skeins, Edridge Green⁴ in 1920 using colored beads. Pseudoisochromatic plates were introduced by Stilling⁵ in 1873. Lantern tests were introduced by Williams⁶ in 1903. Early designs were often used for railway employees. Gradually, lanterns replaced the various wool tests. In a notable rearward action, Abney⁷ (1895) in his evidence to the Departmental Committee on Sight Tests, resisted moves to introduce lantern tests, preferring his laboratory spectral methods.

Lantern tests involve the naming of small lights or “point sources”, usually in a dark room. Lanterns have seldom included blue stimuli, so tritan effects or defects are not likely to be considered. A lantern test is usually more difficult in a bright room. Observing in complete darkness may give the best chance of success. However, there has been evidence that subjects with defective color vision may have poorer recognition of colors in a dark environment hence Holmes and Wright⁸ permitted the use of their Aviation lantern “in moderate room lighting if desired”. A number of electric

lanterns were also developed, notably by Martin^{9,10} (1939, 1943) and by Sloan¹¹ (1944).

Ishihara tests, based on color plates, are a quick way of detecting color vision abnormalities, but are limited in their ability to classify abnormalities. Tests such as the Farnsworth Munsell 100 Hue test are a better method of distinction between various types of defects. However, these techniques are prone to error if ambient lighting is not standardized, and the color pigments used in the tests tend to degrade with exposure to light or contact with sweaty fingers.

Color vision deficiency is a term used to describe a number of different problems people have with color vision. Their incidences are approximately 8% among Caucasian males (Pokorny, Smith, Verriest and Pinckers 1979; Sharpe, Stockman, Jägle and Nathans 1999). These problems may range from a slight difficulty in differentiating between different shades of a color to not being able to identify any color. Most people with poor color vision can't distinguish between certain shades of red and green. Less commonly, people with poor color vision cannot distinguish between shades of blue and yellow. Poor color vision is an inherited condition in most cases. However, eye diseases and the effects of some medications also can cause color deficiency. Men are more likely to be born with poor color vision. Often, a person who is red–green deficient isn't completely insensitive to both colors. Defects can be mild, moderate or severe, depending on the amount of light-sensitive substances missing from the cones. Someone with red–green deficiency may not be able to differentiate the colors of a rainbow or recognize a rose-colored sky at sunrise or sunset.

Interestingly, many people with red–green deficiency are not aware of their problem. Their “green” may be what normal-sighted people call “yellow”, but because they've always heard leaves called green, they interpret what they see as “green”.

There have been a number of attempts to develop methods of color testing based on PC based software. A Toufeeq¹² in 2004 has described an inexpensive PC based system for detection of color defects. Miyahara et al¹³ developed a computerized, automated system to diagnose red green color defects using a CRT screen.

However, there have been no attempts at adaptation of existing tests into computer based software. All the PC based tests described have tried newer methods of testing. We have therefore tried to adapt the existing Martin Lantern test into a software based form (Fig. 1) so that it can be used easily and widely without change of existing norms and standards of color testing in the armed forces.

The details of Martin Lantern and its patent were also accessible on the internet at the website of the European patent office at esp@cenet.

Material & methods

All candidates of SSB, Allahabad, reporting for SMB (Selection Medical board) underwent color vision testing at the eye dept. These candidates were made to undergo the computerized eye test as well to compare the results with various forms of color vision testing currently available. In addition, patients in

the general OPD were also subjected to the above tests to evaluate the results in higher age groups. Results were correlated on Eldridge Green lantern etc by co-investigators.

The study was carried out over a period of 1 year with 921 subjects.

Martin Lantern test distances

1. CP I – 6 m with double spot of size 0.02 in
2. CP III & CP IV – 1.5 m with single spot of size 0.2 in

Software test distances

1. CP I – 5 m with double spot of size 0.02 in
2. CP III & CP IV – 1.5 m with single spot of size 0.2 in

LCD monitor settings

1. Contrast set to maximum and brightness at minimum on a 17" LCD monitor. Monitor resolution was set to max. i.e. 1368 × 768 pixels.

Software preparation

1. The software was prepared in association with a software engineer working in SSB Allahabad.
2. The details of the Martin Lantern were obtained from the original patent of the Lantern, available on the internet on the British Patents site.
3. The RGB system of colors was used to allow projection of pure colors as seen through the Martin Lantern filters.
4. The options available on the software was made exactly similar to the lantern, with options for all spot sizes and color options available at random, with an option for recording the final color grading and maintaining a database of all records.
5. An option for obtaining various reports was also included to facilitate easy data retrieval.
6. Calibration of the software was carried out by testing the software on 100 individuals, including known CP I, AF personnel and candidates who were CP I on the Martin Lantern. The test distance was adjusted accordingly to give similar results by both methods.

Results

A total of 921 cases were examined for various color defects. These included 721 cases of SSB candidates appearing for medicals at MH Allahabad. The computer test after standardization was carried out on an additional 200 OPD cases to verify and compare the results.

The study design was a non-randomized comparative trial.

For this study, all candidates reporting to MH Allahabad for Medical testing were subjected to color testing by standard methods and were then re-tested on the new Martin

Lantern Software for calibration and comparison with existing methods.

All candidates were subjected to Ishihara chart testing and those found to be CP III were subjected to the confirmatory test on Martin Lantern and the Software. Candidates requiring CP I standards for eligibility were tested for the same on Martin Lantern and then cross-checked for the same on the new software method.

The software test, once calibrated, was used to test the color vision on a number of OPD patients to increase the scope of the study and also test it in various age groups. The study tested a total of 921 patients, of which, 721 patients were in the age group upto 30 yrs and the remaining 200 were in the age group above 30 yrs (Table 1, Chart 1). There was no significant difference in sex distribution in both the groups.

On comparison between the Standard Martin Lantern and the Software, the results were consistent and comparable with 82 patients testing CP I on the Martin Lantern and 81 on the software. Of the CP III patients, 253 tested positive on the Standard lantern test as compared to 251 on the software and of the CP IV group, 147 tested positive on the Standard lantern and 149 by the software method (Table 2, Chart 2). Statistical analysis by Pearsons Chi-square test gave a *p* value of 0.98 which was not statistically significant.

All the patients were subjected to Ishihara tests. Of these patients, those found to be CP II, 521 patients, were not subjected to any further tests, if their eligibility criteria did not require higher standards. Of the patients tested on Ishihara charts, 262 were found to be CP III and 138 to be CP IV who were then subjected to confirmatory testing on the

Table 1 – Age group of patients in both the groups.

Age	Standard tests	PC test
Below 20 yrs	380	260
20–30 yrs	341	231
30–40 yrs	34	34
40–50 yrs	24	24
>50 yrs	142	142
Total	921	691

Chart 1 – Age group of patients.

Table 2 – Correlation of test subjects between Martin Lantern and PC test.

Color grading	Martin Lantern	PC
CP I	82	81
CP III	253	251
CP IV	147	149
Total	482	481

Chart 2 – Correlation of test subjects between Martin Lantern and PC test.

Martin software and also the Standard Martin Lantern. The results were consistent between the two methods, however, of these, 11 patients were found to be CP IV and not CP III and of the 262 patients found to be CP III on Ishihara, only 251 were found to be CP III on the PC based test (Table 3, Chart 3). Pearson's Chi-square test analysis and Fisher's exact

Table 3 – Correlation of test subjects between Ishihara charts and PC test.

Color grading	Ishihara	PC
CP II	521	Cannot be evaluated
CP III	262	251
CP IV	138	149
Total	921	400

Chart 3 – Correlation of test subjects between Ishihara charts and PC test.

test gave a *p* value of 0.46 which was not statistically significant.

Discussion

There have been no earlier reported attempts at preparation of a software based equivalent of the Martin Lantern because of development of alternative systems and methods of testing with similar results. However, there have been reports and articles which have developed newer PC based systems of testing.

However, the grading of color vision testing in the armed forces has always been based on the Martin Lantern. With the absence of a viable alternative and no change in the visual standards and methods of testing, there was a need to develop an easily reproducible and widely acceptable method of testing.

The availability of details and patent of the Martin Lantern facilitated the production of a software based alternative with exact reproduction of the spot sizes and colors of the original Martin Lamp. In addition, the spot sizes were measured using a caliper for accuracy in reproducing them on the LCD screen. The computer screen used was a 17" LCD monitor with brightness set to minimum and contrast to maximum to reduce background luminance and at the highest resolution setting of 1368 × 768 to achieve adequate form resolution.

The test method was then calibrated based on known CP I individuals and further comparison of results with the existing methods of testing, i.e. Ishihara and Martin Lantern. It was attempted to achieve a test situation similar in appearance and characteristics to the existing Martin Lantern with exact spot sizes and the distance between two spots in the double spot tests.

The test results between various test types were consistent and reproducible by the software method. A correction of the test distance was required after initial calibration to produce similar results by the Standard lantern and the software method.

The software method was found to be as accurate as the lantern and more accurate than Ishihara charts in picking up CP IV individuals. The software eliminates various factors like filter degradation which has occurred in the lantern over the years. Similarly, the Ishihara charts in use are highly variable in colors and plate qualities leading to ambiguous results. The PC based test gives consistent and accurate color projection which is highly reproducible and repeatable. Variables like lighting conditions, dark adaptation etc are common to both the lantern and PC tests.

However, the PC based test is dependent on monitor characteristics which vary from manufacturer to manufacturer and might lead to differences in contrast and brightness thus affecting test results. This has been attempted to be overcome by issuing instructions to users on monitor size, brightness, contrast etc settings as mentioned.

The software is already under further evaluation at all centers with MLT to further validate it before it is accepted for use in ophthalmology centers of the armed forces.

After validation the software based test can be distributed to all ophthalmology centers of the armed forces thereby

improving availability of the color vision testing facilities, especially CP I, which are currently restricted to only centers having Martin Lantern.

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Conflicts of interest

All authors have none to declare.

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