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Color Perception in Civil Aviation

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ABSTRACT
A disorder known as colour vision insufficiency (CVD) makes it impossible for people to tell some colours apart from others. The Aeronautical Commission of the International Civil Air Navigation Authority developed occupational colour vision requirements in aviation in 1919. In the past few years, worries have been raised about the possibility that the aviation industry's present colour vision requirements are both inconsistent globally and overly strict. The tasks that pilots face in the modern aviation environment are not necessarily reflected in the examinations that are used. Due to this misunderstanding, deserving candidates for selection as aircrew may be disqualified.
Clinical diagnosis tests are used on the ground by medical personnel to determine whether CVD is compatible with aircraft crew. These medical exams were created especially to identify the type, severity, and existence of CVD. There are currently no clinical tests that quantify operational performance when flying an aeroplane. Clinical tests have been given arbitrary pass scores, and those who fail them will either face operating limitations or be completely disqualified.The required clinical exams and the corresponding passing scores differ significantly amongst regulators.An individual may be excluded in one jurisdiction even though they may not be in another. In order to determine the scope of evidence-based recommendations for the minimal colour vision standards for flight crew as well as for civil aviation in India, this article reviews more recent diagnostic procedures used by various nations for evaluating colour vision.

Keywords: Martin Lantern test, Ishihara chart, Colour vision, and Civil aviation

1. INTRODUCTION

In aviation, colour is utilised to decode transmissions, analyze visual cues from runways, and collect data from visual displays. To ensure that the in-flight crew can distinguish between

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and recognise various colours, both on the flight deck and an external stimulus, it is crucial to establish suitable colour vision standards.In the modern era of civil aviation, where the lighting in visual displays inside the aircraft has undergone a significant transformation, concerns about night flying have recently been voiced throughout the world because the current colour vision standards are insufficient because the majority of these tests can only detect typical red and green colour blindness. For flight safety, quick and precise colour vision is required.However, there is room for debate when it comes to the relationship between colour vision deficiency (CVD) and aviation safety, particularly when it comes to the medical evaluation of aircrew. There have been many arguments made against applying CV guidelines to pilots, and one of the more challenging problems with the problem is that there is no generally accepted cutoff point between safe and harmful levels of CVD.

Currently, the majority of civil aviation authorities use colour screening procedures that do not accurately assess the degree of colour vision impairment, making it challenging for authorities and examiners to define cutoff values for the pass or fail limitations.It has been observed that, with a few notable exceptions, a typical trichromat applicant will make a few errors during the Ishihara colour screening. [1]

Research into more precise ways of measuring colour vision sensitivity has been prompted by recent developments in colour vision[2] and the creation of newer instruments to measure precisely the loss of chromatic sensitivity[3]. These developments have led to the establishment of minimum colour vision requirements in aviation.

The capacity to characterise population variability or range that exists within normal colour vision more precisely and to discover minute congenital colour vision deficits that were previously undetectable in older colour vision testing equipment are now both possible thanks to new technology.Compared to vocational testing, these more recent tests are better at quantifying colour vision deficiencies. Squire et alstudy .'s comparing numerous occupational tests in both normal trichromats and a sizable number of color-impaired observers highlighted the limits of occupational colour vision tests. They have emphasised the need for tests that can accurately gauge the range of chromatic sensitivity as well as the predicted diversity in the community of people with normal colour vision. [4]

An ideal colour vision test should (a) reliably isolate different colour signals and provide a numerical assessment of the degree of colour vision loss, (b) be based on population-based data from various races and nations that have statistical thresholds for colour discrimination in "normal" trichromats, so that only individuals who fall outside the range are considered abnormal, and (c) have sufficient sensitivity to identify "minimal" deficiencies and accurately categorise them.

Other widely used techniques outside of the pseudo-isochromatic plate test (such as the Ishihara plates, Dvorine plate test, AO Hardy-Rand-Rittler, and Tokyo Medical College Colour) and lantern test (such as the Martin Lantern, Eldridge-Green Lantern, Holmes-Wright Lantern, and KBB-Martin Colour Vision Testing Lamp) are:

Aviation Light Test (ALT): The Aviation Lights Test is an updated version of the Farnsworth Lantern Test[5] created to comply with the FAA's (Federal Aviation Administration) signal colour specifications for the red, green, and white signal lights on aircraft (USDOTFAA, 1988)[6] and International Civil Aviation Organization (ICAO, 1988)[7]. The candidate is situated eight feet away from the lantern and is given an instrument with nine vertically spaced pairs of coloured lights.18.3 min of arc, or 1.3 cm, separates the two apertures vertically. Red, green, and white are the primary hues that are emitted from the aperture. 27 presentations in total from the aperture. Candidates are shown the fundamental three test light colours from the aperture before to the test to familiarise them. The test calls for a very dark space that replicates the general nighttime lighting conditions of the air traffic control (ATC) tower.

Farnsworth D-15 Test:A test known as an arrangement test is the D-15 test. The goal of the test is to correctly arrange the coloured plates or discs.Color-blind people will find it difficult to arrange the provided colours in a specific pattern and will likely make mistakes. A significant error is when discs are positioned on the incorrect side of the circle. Discs positioned on the same side of the circle in a side-to-side position denote a minor fault or common confusion. If the person makes two minor mistakes, those are deemed within typical bounds, whereas two or more large mistakes are seen as being outside the normal range. The type of colour blindness and its degree can be determined based on the subject's errors and the resulting confusion vector.

Color Assessment and Diagnosis (CAD) Test: A previous CAA record of the USA endorsed the CAD test. [8] Its visual monitor display is calibrated. It emits precisely calibrated chromaticity and saturation coloured stimuli. Each diagonal direction of the visual display is followed by this coloured stimulus that is being displayed.There are four buttons on the subject chairs. The subject's main goal is to report, by hitting buttons at a predetermined distance, the motion direction of the color-defined stimulus. To change the colour signals' strength at random, staircase processes are utilised. According to the subject's responses, computer-controlled software automatically modifies the color's intensity. This creates the red, green, and yellow and blue colour detection thresholds. The CAD test is superior to the traditional test in a number of ways. The strength of the colour signals can be more precisely isolated with this test.

Anomaloscope: The red-green colour deficit is a common condition that can be identified and diagnosed using the premise of anomaloscope, which is based on colour matching.The apparatus generates a stimulus of disc size that is split into two equal halves and is viewed through an optical system. Red and green lights are used to illuminate the upper half of the disc, and spectrally narrow yellow light is used to illuminate the lower half. Two control knobs are located in the base; the upper knob controls the top field's red-to-green colour mixture ratio, and the lower knob controls the luminance of the yellow below field. The exam consists of two phases. The dominant eye (right or left) is first identified for each person and thoroughly evaluated before the remaining eyes are examined.
An updated prototype of an anomaloscope that can additionally identify the blue-green disease is called the Heidelberg Multicolour Anomaloscope (HMC). With integrated automated neutral adaption, the instrument uses a microprocessor-controlled device for precise diagnosis of colour vision in the red, green area (Rayleigh equation) and the blue, green area (Moreland equation). The fact that it delivers results automatically, negating the need for a qualified expert, gives it another edge over other anomaloscopes.

RCCT (Rabin Cone Contrast Test): The RCCT is the only colour vision exam used by the US Air Force and is a special test created to quickly diagnose congenital CVD as well as

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determine its severity. [9] The test can accurately assess the severity of cone insufficiency. The RCCT employs randomly selected red, green, and blue letters that are only visible to certain types of cones (long [L], medium [M], and short [S]). In order to determine the ultimate threshold for letter recognition, contrast is reduced in diminishing phases.

In the RCCT, a score of 75 or more was considered normal. Beginning with one eye in a dark room at a distance of 1 m while wearing corrective lenses, RCCT is performed. The test begins with a random series of 20 red letters (L), then 20 green letters (M), then 20 violet letters (S), progressing from most visible down to least visible once the subject has seen how the L, M, and S letters appear in the centre of the display.The programme chooses letters at random from the visual acuity chart from the Bailey-Lovie Early Treatment Diabetic Retinopathy Study (ETDRS)[12] (H, N, V, R, U, E, D, F, P, Z) The letter is written in Arial bold font. The application displays a coloured letter on each trial, placed within a crosshair on a grey background. The letter appears for 1.0 to 1.6 s (duration increases as contrast lowers), then the grey field appears for an equal amount of time. The subject must read the letter during this time in the grey field before moving on to the next phase of the programme.

The tech records the letters that were correctly read and those that were overlooked. The built-in software calculates and prints the L, M, and S cone scores based on the number of errors made in the projected 20 letters for each testing colour. Each eye must finish the test in three minutes.

Precision Approach Path Indicator (PAPI) Test: Probably the most significant and safety-critical task in aviation that heavily depends on colour vision is the PAPI. Four lights are part of the PAPI system, and they are placed 90 degrees from the runway in a horizontal arrangement. 15 metres distant from the edge is the closest light. A 9 m distance separates each light, which has a 30 cm diameter. Red makes up the lower half of the unit while white makes up the upper half.Red and white lights combined with varied elevation angles are used when an aircraft is approaching on the runway. If an aircraft is flying too low or too high on a certain slope, all lights will be seen as red.

The PAPI simulator test replicates the photometric and angular subtense of red and white lights under difficult viewing circumstances.For this, a dark background is produced. The purpose of this simulator test is to create a real-world scenario and determine the kind and degree of colour blindness. The subject's task in the simulator test is to merely report the number of red lights in the display while four horizontal lights are displayed for three seconds.

Red and white lights are randomly shown in five different patterns. In order to indicate the number of red lights during the PAPI simulator test, observers were instructed to use the following names: 1, 2, 3, 4, or 0. Before beginning the test, observers were given a trial run to help them get used to the low mesopic environment.

OCVA (Operational Color Vision Analysis): Assessments on the ground and in flight make up this test. Each evaluation is done during the day at first, and then if the individual wants to remove the restriction on night flying, it may be done again at night. It involves two steps: A single light test is conducted at an airport ATC tower on the ground. It is a live test where 12 light signals are projected in the colours red, green, and white from an air traffic tower (six from 1000 feet and six from 1500 feet).After the signal has been displayed for 5 seconds, candidates have 5 seconds to respond. b) Chart reading: Aeronautical charts are

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exhibited in the table, and candidates must quickly and accurately read and understand varied sizes and terrain colours.

2. DISCUSSION

Confusion and disagreement persist due to the inconsistent methods used to test colour vision around the world. It happens frequently that a subject will fail the colour vision evaluation using one testing method in one nation while passing using a different testing method in another. If we consider inter-subject variability, numerous circumstances (environment, lighting condition of the same test, contrast, and hue of testing devices that can lead to loss of chromatic sensitivity), and other features of the various colour vision tests, this is not entirely unexpected.

Additionally, it makes candidates more confused and enables them to take many exams in an effort to meet one of the many colour vision criteria. Different nations have devised strange techniques for evaluating colour vision. [10,11] Pseudoisochromatic plates (Ishihara) and the Martin Lantern test (MLT) are now the two most popular colour vision testing techniques used by both military and commercial aviation in India. [12] As previously mentioned, these are not error-free, even when used by regular people undergoing a colour vision exam. [11]In fact, colour plates may be overly discriminatory, according to the International Civil Aviation Organization (ICAO) handbook. [13].Before releasing the MLT results, it is important to carefully examine them and conduct further colour vision diagnostic tests, such as the anomaloscope. [12] Studies, on the other hand, have revealed that there are numerous inconsistencies and inconsistent findings among the various varieties of lanterns. [14] It might not be a good idea to pass the Lantern test in order to be accepted into civil aviation and night flying.

The aforementioned occurrences simply highlight the necessity for establishing standards that can be regarded safe to fly, not that all colour vision deficiencies should be prohibited from flying. The Administrative Appeals Tribunal of Australia has repeatedly found, supported by pertinent studies from the United Kingdom CAA, the United States FAA, and others, that some CVD aircrew are capable of carrying out operational tasks just as competently as people with normal colour vision.NATO advises that rather than focusing on a person's competence to perform clinical diagnostic tests, CVD examinations should measure a person's capacity or competency to crew an aircraft. [12] NATO developed specialised software (PROPOCAT) in 2001 to evaluate a candidate's colour vision using a combination of coloured mazes, coloured puzzles, and aviation-related imagery. However, it is unclear how the coloured mazes and puzzles relate to aviation, thus it doesn't seem like many countries have embraced this technique. [14]

3. CONCLUSION

The goal of this review article is to encourage policymakers to adopt new techniques for evaluating Indians' colour vision accurately and in accordance with international standards, as well as to explore the potential for developing evidence-based recommendations for the minimal colour vision standards for flight crew in civil aviation. MLT is scarcely commercially available in India, and older units have not received maintenance for many years. This raises more doubts about MLT. MLT has been abandoned by many nations in

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favour of other lamps or instruments. The current disparity in colour vision testing procedures and standards demonstrates the urgent need to adopt more objective evaluation methods comparable to those used in developed nations and to establish minimal colour vision standards that are both safe and equitable to applicants for civil aviation. Because of this, establishing algorithms for assessment on color-coded tasks relevant to the aviation environment as well as evaluating innovative tests to supplement occupational assessments with quantitative tests are required in the Indian setting.

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