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Assessment of colour vision

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The relatively high prevalence of inherited colour vision deficiencies and the optometrist's role as a primary care practitioner mean that colour vision defects are likely to be detected in the optometric practice. Some of the tests described in this article are frequently found in practice, but others are rarely seen outside of a university centre or a research institute. The aim of this article is to give an overview of a selection of colour vision tests. The design of these tests will be considered, and their advantages and limitations will be discussed.

Who should be tested for colour vision deficiencies?

All children, but especially boys, should have their colour vision tested at their first eye test. The practitioner should consider the patient's family history of colour vision deficiency, especially if a deficiency occurs on the mother's side (mother's father or brother). Colour vision should also be tested when a patient presents with symptoms that suggest impaired colour discrimination. The practitioner may be asked to assess a patient's colour vision for occupational purposes. Colour vision should also be evaluated when an acquired defect is suspected as a result of an ocular or systemic disease, or a side effect of medication or injury.

General considerations when testing for colour vision defects

Pigment-based colour vision tests are designed to be carried out under a standard source C illuminant but natural or artificial north sky illumination can also be used.[1] Specialised natural light simulators are unlikely to be available in the optometric testing room, so appropriate fluorescent tubes or filtered tungsten globes may be used. These should have a minimum colour temperature of 6500K[1,2] and a colour rendering index of at least 90.[1,2] The effects of using the incorrect illumination are test dependant.[3,4] Although the intensity of light that should be used is often not specified in test manuals, a range of 250-600 lux has been recommended.[1]

The patient should not wear tinted spectacle or contact lenses during the test. Cosmetically tinted contact lenses do not affect the results in individuals with normal colour vision[5,6] but tinted lenses are available that allow a patient with a colour vision deficiency to pass some tests.[7,8] This would be of particular concern when the colour vision test is being performed for occupational reasons. A limited amount of refractive blur will not invalidate the results, but the level that can be tolerated depends on the test that is being performed.[9-11] Nevertheless, for the patient's own comfort, an appropriate refractive correction should be worn. If a congenital colour vision deficiency is suspected, the test can be carried out binocularly, but if an acquired defect is under investigation, the testing should be conducted monocularly.

The patient and the examiner should be careful not to touch the plates or coloured chips used in the test, as this can change the spectral reflectance properties of the pigment. Colour vision tests exploit isochromatic zones and therefore a change in the spectral properties of the pigment can lead to colours falling away from the confusion lines or a change in the luminance, and the test can become invalid. The practitioner should also take care not to unnecessarily expose colour vision tests to light.

Colour vision tests

The main body of this article describes a selection of tests available for the assessment of colour vision. The efficiency of a test is often described in terms of its sensitivity and specificity. Sensitivity refers to the percentage of people who have a colour vision defect that are correctly detected by the test, whereas specificity is the percentage of people who have normal colour vision that are correctly diagnosed as normal. The anomaloscope is the definitive test for red-green colour vision deficiencies against which the results of other tests are compared. Therefore, even though an anomaloscope is unlikely to be found in an optometric practice, it is the first test described below.

Anomaloscope

The anomaloscope allows evaluation of an individual's Rayleigh matches, ie the proportions of red and green light that need to be mixed to match a yellow.[12] The currently available Neitz OT and Oculus Heidelberg anomaloscopes are designed to perform in the same way as the original Nagel anomaloscope, which is no longer available.[13]

The patient is presented with a bi-field, one half composed of a mixture of red and green lights, the other a yellow light (Figure 1). The proportion of red and green lights in the mixture and the intensity of the yellow light are adjustable. The patient can be asked to perform free matches, ie control both the top and the bottom field until a match is obtained. However, more commonly, the practitioner sets the red/green mixture and the patient will attempt to make a match by changing only the luminance of the yellow field.

An observer with normal colour vision will accept only a narrow range of matches. With a scale of 0 (pure green) to 73 (pure red), the normal match will be around 42 units.[13] The anomalous trichromat will need a different proportion of red and green lights to match the yellow than the normal observer; the protanomalous observer will need more red in the mixture whereas the deuteranomalous trichromat will need more green (Figure 1). The dichromat will be able to match the yellow to a pure red, pure green and all mixtures in between by simply adjusting its intensity (Figure 1). Protan observers will turn down the intensity of the yellow light when matching the field to a red one. This is caused by their reduced sensitivity to red light. A Rayleigh equation anomaloscope will therefore separate normals from colour deficient observers, protans from deutans and anomalous trichromats from dichromats.

Most anomalous trichromats will show not only a shifted mid-point but also a greater range of accepted matches than individuals with normal colour vision. The extent of the matching range is an indicator of the severity of the defect, with a larger range reflecting a more severe defect.

Attempts have been made to develop equations for the evaluation of tritan deficiencies,[13,14] but these have been problematic, as the region within which the match has to be made is trichromatic, and is also subject to the effects of lens and macular pigments. The Oculus Heidelberg Mk 2 anomaloscope incorporates the Moreland equation: a mixture of blue and green lights to match a blue-green light.[14]

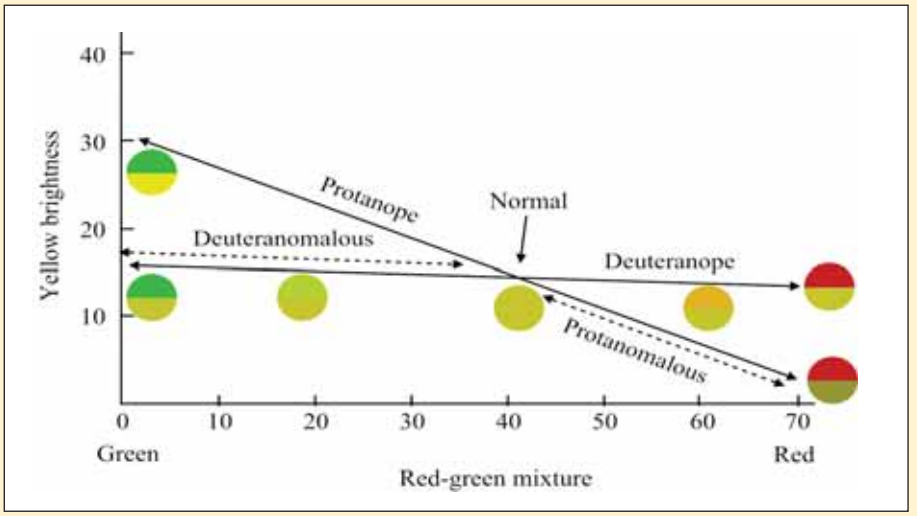

Figure 1
Colour matches made on the anomaloscope by colour normal and colour deficient observers. (Adapted from Birch[1])

Ishihara pseudoisochromatic plates

The Ishihara test is considered to be the most frequently used test to screen for red-green colour vision deficiencies.[13] The design of the Ishihara pseudoisochromatic plates is based on the plates of Stilling. The figure and the background are made up of discrete discs that vary in size and luminance. The use of discrete patches

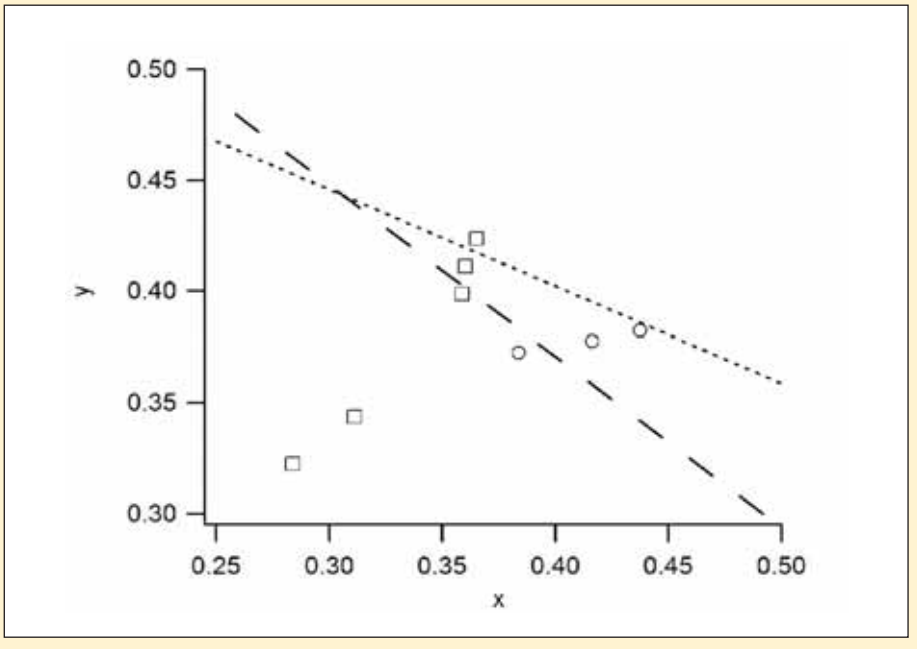

Figure 2
Chromaticity coordinates of the dots used in some vanishing plates of the Ishihara test: (□) background, (○) figure. (Based on data from Lakowski[59]). Protanopic (.....) and deuteranopic (_ _ _) isochromatic lines are also shown.

Figure 3
The Farnsworth D15 Test

with a luminance variance ensures that the figure can be identified only by its chromatic difference from the background and not a difference in the perceived luminance. In theory, this can also be achieved by printing the figure on an isoluminant background. However, it would be difficult to avoid luminance edge artefacts and isoluminance planes vary between observers, so what appears as isoluminant to one person may not be isoluminant to another.

The full edition of the Ishihara test comprises 38 plates: 25 plates have numerals and 13 plates have pathways. The test is also available as an abbreviated version with 24 plates (17 numerals and 7 pathways) and a concise version with 14 plates. The Ishihara test has been reprinted many times since it was first published in 1917. Differences in the chromatic properties of the different versions have been reported[15] but these do not significantly affect the efficiency of the test.[16]

The Ishihara test is carried out at 66cm or arms length. The maximum viewing time is 4 seconds per plate. The patient should be instructed to read the number(s) seen on each page and should be informed that on each page, either none, one or two digits may be seen. When the pathways are used, the patient is asked to trace the coloured path (eg with a brush) between the two 'X' marks on the page.

There are five plate designs in the Ishihara test. The first plate is an introduction plate. Everyone should see the number on this plate as the figure can be differentiated from its background based on luminance cues alone. The plate is used to check that the patient has understood the instructions and can also be used to identify malingerers.

The next series of plates are transformation plates. In these plates, a person with a colour vision deficiency will see a different number than that seen by someone with normal colour vision. Some of the chromaticities that form the background and the figure fall on the dichromatic confusion lines, whereas others fall off the lines. This clever design allows the colour deficient individual to see a figure, although a different one to that seen by the colour normal.

The next set of plates are vanishing plates as these numbers will be seen by those with normal colour vision but not by the colour defective person. The design of these plates relies on selecting colours of the background and the figure from the protan and deutan confusion zones (Figure 2).

In the hidden plates, a number should be reported by a patient with a colour vision defect but not by someone with normal colour vision. The number is not visible to those with normal vision because they can perceive the variance of chromaticities along the long wavelength/medium wavelength (L/M) axis. This variance is not perceived by those with a colour deficiency. Hidden digit plates seem to work better for deuteranopes than other colour deficient individuals but they have an overall sensitivity of only around 50%.[17]

Classification plates are used when the screening section of the test identifies the presence of a colour vision defect. A person with a protan defect will see only the digit on the right hand side, whereas a person with a deutan defect will see only the one on the left hand side. The classification plates are more effective for deuteranopes than protanopes, with a correct classification possible for around 90% of deuteranopes and around 80% of protanopes.[17] A considerable percentage of people with anomalous trichromacy will report seeing both digits. Birch[17] reported that when classification was made only when the anomalous trichromat reported seeing a single digit, 47% of protanomalous trichromats and 57% of deuteranomalous trichromats were classified correctly.The efficiency of classifying anomalous trichromats increased when patients who saw both digits were asked about the relative visibility of the two figures and the one that was more visible was used to arrive at a diagnosis. A correct classification of the defect could then be obtained for over 90% of anomalous trichromats.[17]

Some of the digits of the Ishihara test are particularly susceptible to misreadings.[16,18,19] Atypical errors (ie incorrect responses but not ones that would be expected from an individual with a colour vision deficiency) occur frequently for plates number 4, 9, 13 and 17 of the full edition (and where available, the corresponding plates of the 24 plate edition). The atypical errors are often misreadings of the digits, eg a 73 being read 78 (the colour deficient individual would not see any digits on this plate). As many as 40-45%[16,18] of adults with normal colour vision make at least one misreading on the Ishihara plates. The percentage of children who make at least one misreading is even higher.[19]

Based on a fail criterion of three errors on the transformation and vanishing plates, the sensitivity of the Ishihara test is around 99% and the specificity is 94%.[16,17] The practitioner can easily

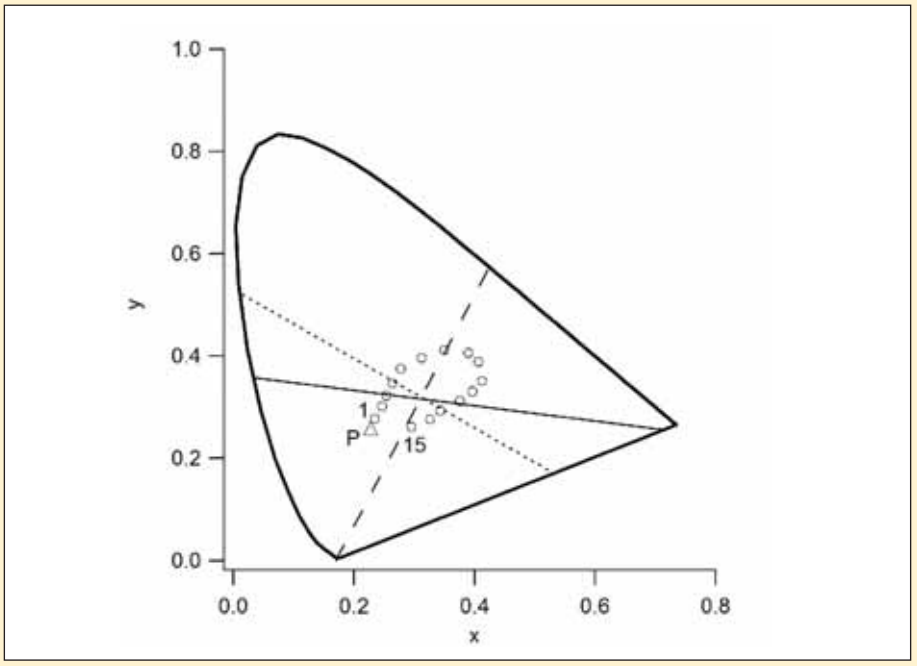

Figure 4
Chromaticity coordinates of the chips used in the Farnsworth D15 test. Dichromatic isochromatic lines are also shown: protan (____), deutan (.....) and tritan (_ _ _ _).

differentiate the typical and atypical errors and therefore the 6% of individuals with normal colour vision should not be misclassified. In fact, the number of errors made by colour deficient patients is usually substantially greater than three.[17] The recommended fail criterion on the 24 plate edition is a minimum of two errors.[1] When administering the test, it is important to remember that the number of errors made by a colour deficient individual is a poor indicator of the severity of the defect.[13]

The pathway plates found in the second part of the Ishihara test were designed for children. However, these are considered to be too difficult for children[1] and other tests have been developed specifically for the assessment of colour vision in these patients (see later).

Hardy-Rand-Rittler pseudoisochromatic plates

The original edition of the Hardy-Rand-Rittler (HRR) pseudoisochromatic plates (American Optical HRR) is no longer available. The currently available products are the fourth edition manufactured by Richmond Products (Richmond HRR) and the Waggoner HRR.[13] The test comprises demonstration, screening and grading plates for protan, deutan and tritan deficiencies. The plates show symbols of a cross, a circle or a triangle on a grey background. In the grading plates, the colours vary in saturation. A colorimetric analysis of the Richmond and Waggoner HRR plates indicated that the colours are well aligned with the dichromatic confusion lines.[20] When a criterion of two or more errors on the screening plates was used to indicate failure, the sensitivity of the Richmond HRR test has been reported to be 100% and the specificity to be 96%.[21] The classification of the defect was correct in 86% of patients.

City University Test

The City University Test contains plates for the detection of protan, deutan and tritan deficiencies. In the first and second editions of the test, the patient is shown a colour surrounded by four other colours. The patient is asked to indicate which of the peripheral colours most closely resembles the central one. Three of the peripheral colours lie on the dichromatic confusion lines, with one on the protan, one on the deutan and one on the tritan line. The fourth colour is one that would be most similar to the central colour for the individual with normal colour vision. An analysis of the responses made by colour deficient patients with the 2nd edition of the test indicated that people with protan defects tend to perform better than those with deutan defects.[22] All deuteranopes and 96% of protanopes failed the test. However, only 44% of deuteranomalous trichromats and 27% of protanomalous trichromats failed. The test can therefore be used to successfully identify individuals with a more severe red-green colour vision deficiency. The number of errors made by deutans can be used to grade the severity of the defect.[22]

The third edition of the test has an additional screening part.[23] In this first part of the test, the patient is presented with triplets of colours and is asked to indicate whether all three colours are the same. Some of the triplets are identical, but in some a differently coloured spot is present. A patient with a colour vision deficiency may miss some of the differently coloured spots whereas an individual with normal colour vision should score 9 or 10 out of 10. The design of the plates in the second part of the test follows that of the first two editions, with four out of the six plates being taken from the second edition of the test.[1]

Farnsworth Dichotomous Test for Colour Blindness (D15)

The Farnsworth D15 test is an example of an arrangement colour vision test. The test is conducted at 50cm and comprises 16 Munsell hues selected from an incomplete circle, mounted onto chips (Figure 3 and Figure 4). The patient is asked to arrange the 15 movable caps in a natural progression of colours, beginning with the fixed 'Pilot cap'. Once completed, the patient should be allowed to review their arrangement and to make changes. As some colour pairings from opposite sides of the hue circle fall on dichromatic confusion lines, a colour deficient observer may place those colours next to one another. The

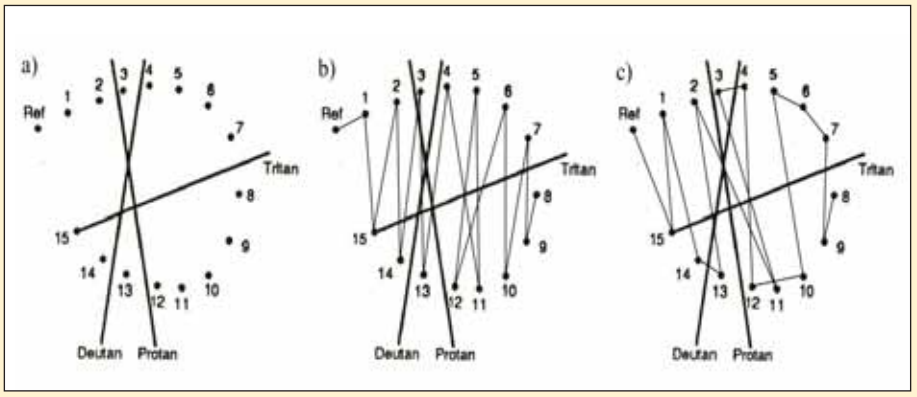

Figure 5
(a) The orientation of the crossovers made by protan, deutan and tritan observers on the D15 test (b) Example of a result obtained by a person with a deutan defect (c) Example of a result obtained by a person with a protan defect.

perceptual steps between the adjacent hues in this test differ, as do those between the hues that may be confused by the colour deficient observer. The test can be used for the detection of protan, deutan and tritan defects.

The aim of the Farnsworth D15 test is to separate individuals into two groups: 1) those with normal colour vision or a mild colour deficiency, and 2) those with a moderate/severe colour vision deficiency.[24] The test may be recommended for the assessment of an individual's ability to perform an occupation in which identification or discrimination of surface colours is required. Research suggests that it does a reasonable, although not a perfect, job of predicting the ability of an individual to name surface colours.[25,26]

The results of the test are plotted on a circular diagram and a diagnosis is made based on the number and direction/orientation of crossovers (Figure 5). A number of pass/fail criteria have been recommended for the D15 test, with one diametrical crossing often being allowed for a pass.[27] However, Birch[28] recommends that a pass should be awarded for a circular diagram only but allowing for a single transformation between adjacent hues. Using this criterion, 1.5% of dichromats and 63% of anomalous trichromats passed the test. If the result contains only one or two lines across the diagram, a retest should be performed. Allowing one red-green isochromatic crossings increased the pass rates to 3% for dichromats and 73% for anomalous trichromats. The repeatability of the results in individuals with a colour vision deficiency is around 80% with regards to the pass/fail outcome and classification of the defect.[29,30] More quantitative methods of analysing the results have been proposed but these are rarely used in clinical settings.[31-33]

Desaturated D15 tests

Manipulation of the Munsell chroma and/or value of the chips has led to the development of a number of other D15-type arrangement tests. In the Adams desaturated D15 test, the chroma has been reduced from 4 to 2, whereas in the Lanthony desaturated test the value has also been increased, from 5 to 8.[13] These changes in Munsell characteristics lead to smaller differences between the chips. The tests are therefore more difficult and patients with a mild colour vision deficiency who would pass the standard D15 test may reveal themselves on the desaturated test.[34]

Farnsworth Munsell 100 Hue Test

The test was developed in the 1940s and comprises 85 chips[35] (Figure 6). The caps are grouped into four boxes. In each box, two caps are fixed and the patient is asked to arrange the remaining ones to form a gradual progression between the two fixed caps. The caps in each box come from a different part of the chromaticity diagram.

The analysis of the results is based on the scores assigned to individual caps. The score assigned to each cap is the sum of the absolute differences between that cap and the two caps placed either side of it. For example, to calculate the score for cap 15, when the caps are arranged as 13, 15, 16, the absolute difference between 13 and 15 would be added to the absolute difference between 15 and 16 giving 3. The baseline score when the caps are arranged correctly is 2. Once the score for each cap is calculated, it can be represented on a polar plot. A diagnosis of the type of colour vision deficiency is based on the pattern of errors revealed on this plot. Protan, deutan and tritan observers will make errors in regions where the caps fall on isochromatic lines for the particular class of colour deficiency and the polarity of the plot can therefore be used to arrive at the diagnosis (Table 1). In a study by Birch,[36] a correct diagnosis based on the polarity of the plot was obtained for almost all dichromats and 50% of anomalous trichromats. As the Farnsworth Munsell 100 Hue Test samples colour from the entire hue circle, it can be extremely useful in the assessment of acquired colour deficiencies that often cannot be classified as protan, deutan or tritan defects.

	Mean position of the centre cap	Range
Protanopes	17 64	15-26 58-68
Deuteranopes	15 58	12-17 53-60
Tritanopes	5 45.5	4-6 45-46

Table 1
Positions of the centre caps that define the axis of confusion on the Farnsworth Munsell 100 Hue Test.[1]

The total error score is the sum of all the error scores for the individual caps (score - 2). This score is influenced by the patient's age and improves up to about 20 years of age and then deteriorates, especially in the later decades of life.[37] Performance on the test is also influenced by learning,[38] illuminance,[39] and differences in macular pigment.[40,41]

Lantern Tests

Although lantern tests are not used routinely in optometric practice, they are sometimes recommended for the assessment of colour vision for occupational purposes, especially for the railway, aviation and maritime industries. The lanterns are designed to mimic real life situations in which colour naming is required. The patient is presented with one or two lights at a distance and has to name them as soon as they are presented. Red, green, white and sometimes yellow lights are used. The majority of patients who fail the Ishihara test also fail the Holmes Wright Lantern (recommended for use in the UK) and the Farnsworth Lantern (Falant) (recommended for use in the USA).[42,43]

A new lantern, the CAM lantern, has recently been developed.[44,45] The design principles of the CAM lantern are based on the traditional lanterns, but the new test benefits from (optional) computer control and therefore parameters such as aperture size and sequence of presentation can be easily manipulated.

Medmont C-100 test

The Medmont C-100 test (like the no longer available OSCAR test) utilises flicker photometry to measure the relative spectral sensitivity for red and green lights.[46] The patient is presented with flickering red and green lights and is asked to adjust their relative intensity to eliminate or minimise the flicker. The strength of this test lies in its great ability to differentiate between protan and deutan defects, as protan defects will be revealed by reduced sensitivity to red light. The settings are robust, the results of the classifications are highly repeatable and there is very good agreement of the classification compared with the anomaloscope.[47,48] The test can also be used to detect carriers of protan deficiency who have reduced sensitivity to red light and therefore show a protan-like setting.[49]

Cambridge Colour Vision Test

The Cambridge Colour Vision Test is an example of a commercially-available computerised test. Computerised colour vision tests offer the advantage of being able to dynamically adjust the level of difficulty depending on the patient's performance. The order of presentations can also be easily randomised, so the patient cannot memorise the correct answers. However, the display needs to be presented on a calibrated monitor to ensure an accurate representation of colours.

The design of the display used in the Cambridge Colour Vision test is based on the pseudoisochromatic plates of Stilling or Ishihara, but the test uses a Landolt C as the target (Figure 7). The patient's task is to indicate the orientation of the gap in the C.[50] The test can be used as a screening tool, in which the patient's ability to discriminate colours along protan, deutan and tritan confusion lines is measured. A more detailed analysis of the patient's colour vision can also be performed, which involves measuring colour discrimination along other directions in colour space. This is particularly useful in the assessment of acquired colour vision defects.

Web-based Colour Assessment and Diagnosis (CAD) Test

A number of colour vision tests are available on the World Wide Web. However, most of those have not gone through an evaluation process and results obtained with such tests must be treated with caution.

The web-based Colour Assessment and Diagnosis (CAD) Test[51] is an example of a test that has been evaluated. In the web-based version of the CAD test, the patient watches a 90-second movie and is required to report whether a moving coloured square disappears at any time during this period. The disappearance signals failure. When compared to the results obtained with the anomaloscope, the specificity of the web-based CAD test was found to be 100% and the sensitivity 93%. The degree of repeatability from two sessions was 98%.[52]

Assessment of colour vision in children

Screening for congenital colour vision deficiencies will often be performed on young children. Specialised colour vision tests have been designed for this purpose. These use simpler and more familiar shapes than those used in the standard colour vision tests.

The Ishihara test for unlettered persons comprises four plates that contain geometric shapes of a circle or a square, and four plates that contain simplified pathways.[53] The two transformation plates that present geometric shapes have high specificity and sensitivity when used in adult patients.[16] The test can be attempted with children as young as three-years-old but the child may need to be allowed to trace over the shapes, use replicas, or be allowed more than one attempt.[53] The pathway designs can also be completed by most young children but classification of the defect may not always be possible.

Colour Vision Testing Made Easy (Figure 8) test is a pseudoisochromatic plate test designed to screen children for red-green colour vision deficiencies.[54] In each plate, a simple figure or shape is made from discrete patches. A demonstration plate is provided that can also be used by the

Figure 6
The Farnsworth Munsell 100 Hue test.

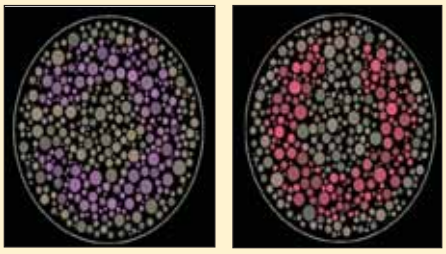

Figure 7
Examples of the displays used in the Cambridge Colour Vision Test (courtesy of JD Mollon)

child as a matching card. The test comprises two parts and each part can be used as a stand-alone test. The first part of the test requires the child to identify simple shapes: a square, a circle or a star. In six out of the nine plates, a child with a colour vision deficiency can identify one of the shapes on the page; a child with normal colour vision sees two or three shapes on the page. This design allows the child with a colour vision deficiency to give a response and also indicates to the practitioner that the instructions have been understood. On the other plates, the child with a colour deficiency will not see a shape. The second part of the test uses simple objects: a boat, a dog and a balloon. The child with a colour deficiency will not see the objects. Although this part of the test has been designed for very young children, greater success has actually been reported with Part 1 than Part 2 in children between the ages of 3-5 years.[55]

Figure 8
Colour Vision Testing Made Easy (courtesy of Kay Pictures)

The efficiency of the test has been evaluated in adult patients.[54,56] When a pass criterion of 8 out of 9 plates in Part 1 and 3 out of 3 plates in Part 2 was used, the test had 100% specificity and 91% sensitivity. It has been suggested that Part 2 can be used for fast screening, as it comprises only three plates. Part 1 can then be used only if a child fails to respond when the three plates of Part 2 are shown, to check that the lack of responses is not the result of a lack of understanding. The test has also been successfully used in colour vision screening of individuals with intellectual disabilities.[57]

The Neitz Test of Colour Vision is a pen-and-paper test that screens for protan, deutan and tritan defects.[58] The test comprises a demonstration panel and eight test plates, and includes classification plates. The plates are a hybrid of a transformation and a vanishing plate. In each panel, a figure is made up of discrete coloured patches and a second figure from a luminance cue. A small amount of luminance noise is also present. The child is asked to pick out the figure formed by the coloured spots and can either outline the figure or pick it from the available responses. A child with a colour vision deficiency may select the figure formed by the luminance cue or select no figure at all. The test has been successfully performed on children as young as four-years-old and has been shown to have a high level of success in detecting colour vision defects. The pen-and-paper nature of this test allows it to be used to screen a large group of children at the same time (eg in a classroom situation). However, the mass production of test sheets needs careful control of the printing process.

A child's colour vision can also be tested by modifying the standard colour vision tests and/or modifying the instructions. When using the Ishihara test, single digits should be used, either by selecting the plates that only have a single digit or by covering one digit when two digits are present.[1] The child could be allowed to trace the digit (without touching the page, but, for example, by using a paint brush) or cut outs could be provided, so the test is then one of matching. When using the D15 test, the instructions can be modified so that the child is asked to find the most similar colour to the last chip in the box.

Which test to use?

The choice of test will be determined by the initial reason behind the assessment of the patient's colour vision. In most instances, the assessment will be carried out to determine whether a colour deficiency is present. If a congenital red-green defect were suspected, the Ishihara test would be the test of choice. If a tritan defect is suspected, the City University Test is most likely to be found in practice. A classification of the defect may be possible at the same time, but the anomaloscope will be needed to differentiate between anomalous trichromats and dichromats. A battery of colour vision tests is often employed to grade the severity of the defect. Testing for occupational purposes usually requires the use of specific tests that are likely to be set by the industry in question.

Conclusion

The optometrist is likely to be the health care practitioner who will make the initial diagnosis of a colour vision deficiency. In order to screen for colour vision deficiencies, the practitioner must be aware of the correct procedure to carry out the test and how to interpret the results, bearing in mind any limitations of the test that is being used. If a more thorough analysis of the defect is required, the patient may need to be referred to a specialist clinic if appropriate tests are not available in practice.

About the author

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References

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Module questions

Course code: C-11998

Please note, there is only one correct answer. Enter online or by the form provided

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1. Which of the following statements about the lighting that should be used when assessing colour vision is TRUE?
a. Only standard source C illuminant should be used
b. Only tungsten lighting should be used
c. Only specialised daylight simulators should be used
d. Fluorescent tubes may be used

2. When describing the efficiency of a test, sensitivity refers to:
a. The percentage of people correctly identified as having a defect
b. The percentage of people correctly identified as not having a defect
c. The percentage of people who have a defect but are not identified
d. The percentage of people who do not have a defect but are identified as having one

3. What state of colour vision does a patient have if they are able to match all mixtures of red and green lights to a yellow light by simply adjusting the intensity of the yellow light?
a. Normal trichromat
b. Protanomalous trichromat
c. Deuteranomalous trichromat
d. Dichromat

4. If a patient is identified as having a colour vision defect by the vanishing and transformation plates of the Ishihara test but reports seeing both numbers on the classification plates, which of the following is TRUE?
a. The defect cannot be classified
b. The patient is malingering and is actually a normal trichromat
c. The defect can be classified if the patient is asked about relative visibility of the digits
d. The pathway plates should be used to classify the defect

5. Which of the following statements about the Ishihara test is TRUE?
a. All plate designs have the same sensitivity
b. Misreadings by colour normal patients can occur
c. In the transformation plates, a patient with a colour vision should not see a number
d. The number of errors made is a good indicator of the severity of the defect

6. Which of the following groups is most likely to fail the Farnsworth D15 test?
a. All deutans and protans
b. Deutans and protans with a moderate or severe colour vision deficiency
c. All protanomalous trichromats
d. All deuteranomalous trichromats

7. How is the type of colour vision defect determined when analysing the results of the Farnsworth Munsell 100 Hue test?
a. By the number of errors made
b. By the average error score
c. By the total error score
d. By the polarity of the error plot

8. Which of the following statements about the Farnsworth Munsell 100 Hue test is TRUE?
a. Performance is independent of the patient's age
b. Performance improves with age up to the late decades of life
c. Performance peaks at an age of about 40 years and then declines
d. Performance peaks at an age of about 20 years and then declines

9. The Medmont C-100 test is an ideal test to differentiate which type of colour vision defect?
a. All colour defects from normal colour vision
b. Protans from deutans
c. Protanomalous trichromats from protanopes
d. Deuteranomalous trichromats from deuteranopes

10. When assessing colour vision in children:
a. Valid results are only obtained after the age of five years
b. Standard colour vision tests with modified instructions can be used
c. The pathway plates of the Ishihara plates are the test of choice
d. Only tests developed specifically for children can be used

11. Which of the following is the test of choice when screening for red-green colour vision deficiencies?
a. D15 Test
b. Ishihara Test
c. Farnsworth Munsell 100 Hue Test
d. City University Test

12. Which of the following is the test of choice to differentiate an anomalous trichromat from a dichromat?
a. Anomaloscope
b. Ishihara Test
c. D15 Test
d. City University Test

Please complete online by midnight on December 18 2009 – You will be unable to submit exams after this date – answers to the module will be published on www.optometry.co.uk