Australian Orthoptic Journal 1991; 27: 25-36

A REVIEW OF THE FARNSWORTH MUNSELL TYPE COLOUR VISION TESTS

ANNE FITZGERALD, DipAppSc(Cumb), DOBA, MPH(Syd).
University of Sydney, Dept Clinical Ophthalmology. Save Sight and Eye Health Institute

Abstract

This paper outlines the use of the Farnsworth Munsell (FM) type tests. It discusses the FM 100 hue, the FM D-15, the City University, the Lanthony Desaturated D-15, the Roth 28 hue and the Farnsworth F2 Tritanopic Plate tests. With the exception of the 100 Hue test these tests cannot be used in isolation to screen for congenital or acquired colour vision loss.
If a patient is found to have congenital colour blindness (ie congenital anomalous trichromatic colour vision) the Farnsworth tests can be used to give a qualitative assessment of the defect. The FM 100 Hue test is the only one to give a quantitative assessment of the defect. (The 100 Hue can also be used as an isolated screening test although it is an extremely time consuming procedure). For suspected acquired defect the Roth 28 test can be used as a starting point but it should always be followed by a 100 Hue test as it is very important to quantify the defect to monitor any progress.
The paper suggests appropriate clinical investigation protocols for screening and evaluating colour vision deficiencies.

Key words: *Farnsworth Munsell, FM 100 hue test, FM D-15 test, City University test, Lanthony Desaturated D-15 test, Roth 28 hue test, Farnsworth F2 Tritanopic Plates, colour vision screening.*

INTRODUCTION

The Farnsworth Munsell (FM) type tests examine the subject's ability to discriminate between hues which differ by a small amount when viewed under constant illumination. In the Munsell system colour is described in terms of hue (the wavelength of the light), chroma (the saturation or strength of colour) and value (the proportion of black and white light). There are a number of tests in the FM type test series including the FM 100 hue, the FM panel D-15 test, the City University colour vision test, the Lanthony desaturated D-15 test, the Roth 28 hue test and the Farnsworth F2 Tritanopic Plate test. All the above-mentioned tests (except the F2 Tritanopic Plate) use coloured targets of different hues which are selected from the range of 100 coloured papers originally manufactured by the Munsell Colour Company. (The Lanthony Desaturated Test uses desaturated coloured papers).

Any colour deficiency can be classified using the FM type colour vision tests because colour defective patients normally have greatest difficulty with those parts of the spectrum which are complementary to their deficiency. For example a subject who has a red green deficiency will have greatest difficulty with subtle shades of blue or yellow as both these colours are 'made up' from a mixture of small proportions of red and green. These small proportions of red and green are poorly perceived by subjects with red green deficiency.

This paper discusses the FM tests with a view to suggesting appropriate clinical investigation protocols using the Farnsworth Munsell and

Address for correspondence: Anne Fitzgerald, Department of Clinical Ophthalmology, 1st Floor, Sydney Eye Hospital, Woolloomooloo, 2011, Australia.

other colour vision tests for patients with suspected colour vision anomalies.[1]

FARNSWORTH MUNSELL 100 HUE TEST (FM 100 hue)

The FM 100 hue has been designed to detect all types of colour vision abnormality from the mildest red green defect to total achromatopsia. According to Farnsworth[2] its primary uses are, firstly, to separate persons with normal colour vision into classes of superior, average and low colour discrimination and secondly to measure the axes or zones of colour confusion in patients with defective colour vision.

The FM 100 hue test is a test of hue discrimination consisting of 85 caps of perceptually equal differences in hue. When placed in the correct order in a circle the 85 caps form a perfect hue circle of the visual spectrum. The hue circle is divided into 4 parts (one part per box) for the testing. Each has an additional fixed or pilot cap at either end of the box and 22 or 21 loose caps. The 4 boxes render it impossible to make errors across the hue circle so patients cannot confuse reds with greens or blues with yellows.

Subjects with normal colour vision arrange the caps in order of hues between the pilot caps in each box with a few errors but patients with anomalous colour vision make errors in the boxes that are complementary to their deficiency. Contrary to popular belief there is NO time limit on performing the test.[2] In every FM test the caps have a hue spot in the centre which is 1.2cm in diameter and subtends 1.5° at the nodal point when viewed at 50 cms.

Once completed each box is shut and inverted then reopened. A number is seen underneath each cap. The order in which the patient has arranged the caps is recorded. The score for each individual cap is calculated by summing the difference between adjacent caps. For example if the cap order was '2', '4', '8', '5', '3', '6', '7' etc the score for cap '4' would be as follows

The absolute difference between the preceding cap '2' and cap '4' is 2.

The absolute difference between cap '4' and the following cap '8' is 4.

The sum of the absolute differences is $2+4=6$ hence the score for cap '4' is 6.

With this method of scoring the minimum score for any cap is 2. For example if the cap order was '8', '9', '10', '11', '12' etc the difference between adjacent caps is 1. The sum of the absolute differences is $1+1=2$. This corresponds to the lowest score marked on the vertical axis of the score sheet.

The total error score is also calculated for the FM 100 hue test by adding the scores for each individual cap. As there are 85 caps with a minimum score of 2 per cap a perfect score is 170 (or $85\times2=170$). Some clinicians refer to a perfect score of '0'. To do this they subtract 2 from the individual score for each cap thus in the above example the score for cap '4' would be 4 (or $6-2=4$). Alternately they subtract 170 from the total error score. For example, a total

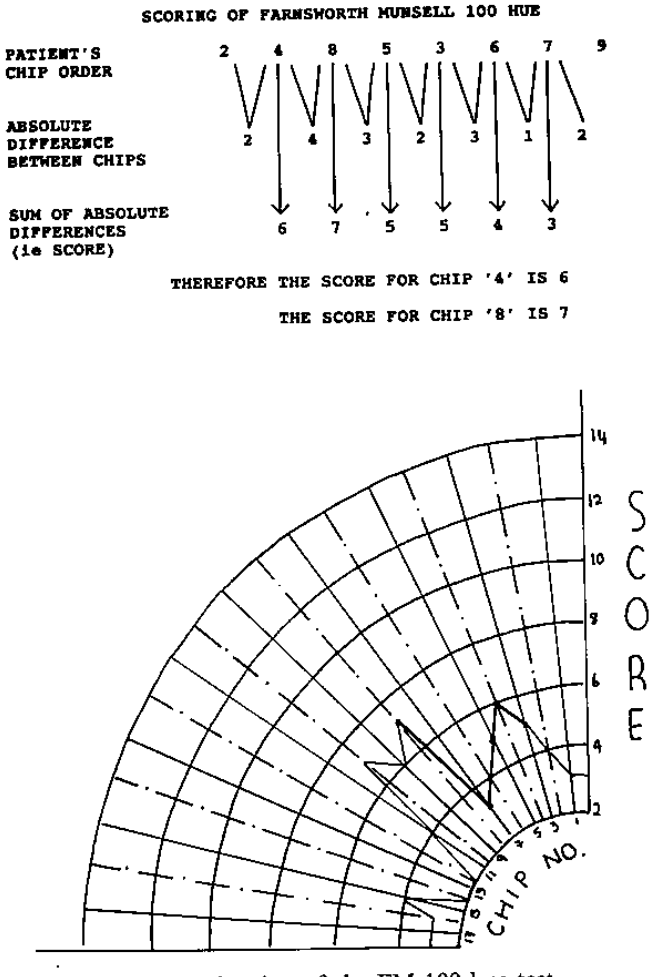

Figure 1: Scoring of the FM 100 hue test.

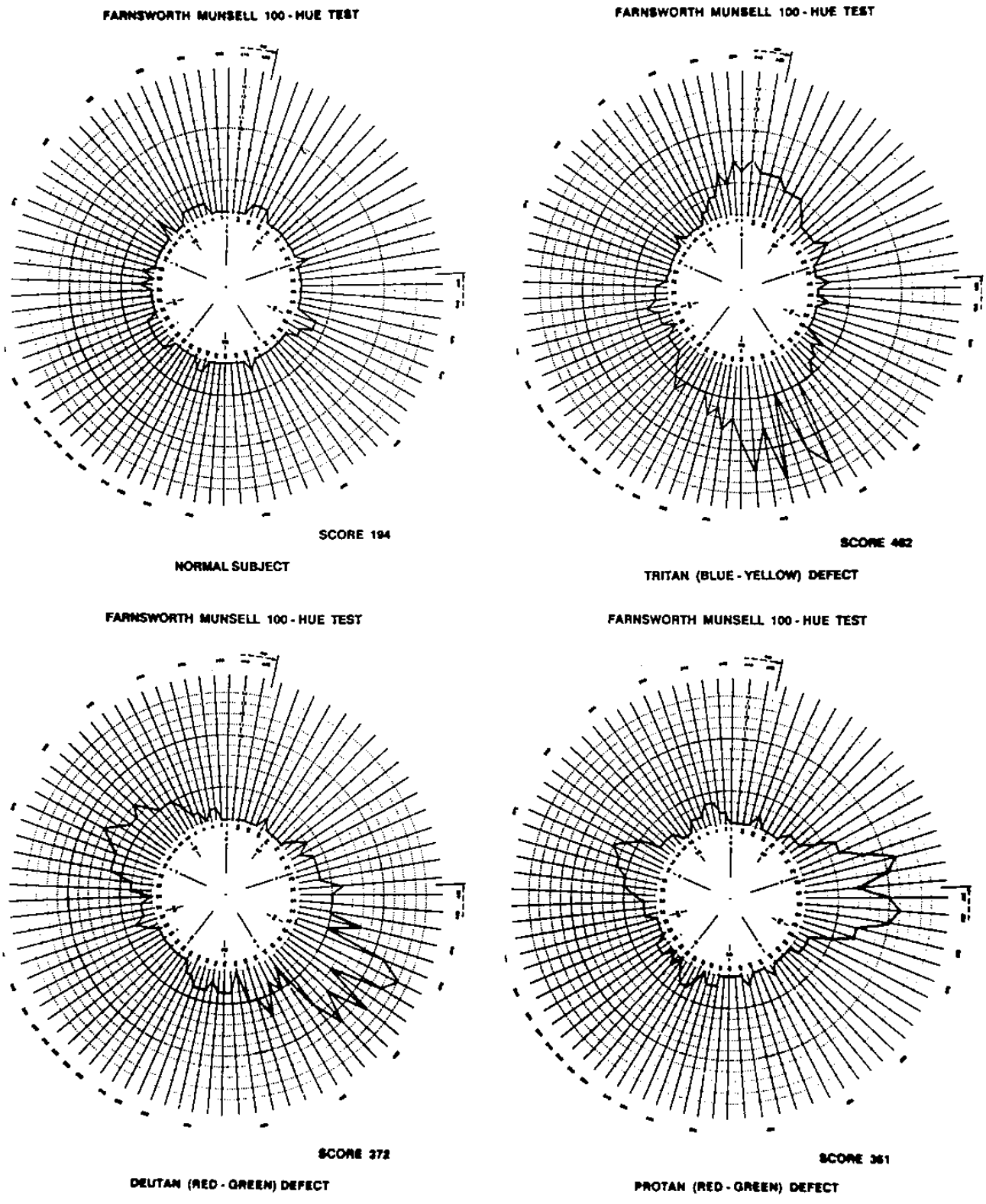

Figure 2: Typical FM 100 hue test error patterns.

error score of 275 is the same as a total error score of 105 (or 275 – 170 = 105).

According to the manual a perfect score is 170, superior discrimination occurs with a score of 171-186, normal discrimination occurs with a score of 190-270 and low discrimination occurs with scores above 270 and no particular zones of loss. The absolute error score increases with age showing the deterioration in colour appreciation which occurs with increasing age. Optimal colour discrimination occurs between the ages of 16 and 35.[3] After 55 years of age, fine colour discrimination is impaired especially blue yellow or violet, blue green discrimination.

Although some clinicians only refer to total error score when discussing FM 100 hue test results, the score alone tells the examiner nothing about the type of colour vision anomaly. To be able to differentiate the various anomalies the clinician must plot the individual scores on the FM 100 hue test graph. The inner circle of the graph gives the cap number and the vertical axis at 12 o'clock gives the score (see figure 1). When the patient has normal colour vision the plot is around the inner circle. The areas of high score in patients with anomalous colour vision are usually clustered together along certain axes known as poles of confusion (see figure 2). When there is a clustering of errors along poles in two regions which are almost opposite then the type of colour vision defect can be diagnosed.

The position of the mid points of the pole regions is also of diagnostic value. Protans or so called red 'blind' patients (protanomalous or protanopic) have a midpoint between caps 62 and 70 thus this is their greatest area of trouble. These are the bluish-purple to purple caps in boxes 3 and 4. Protan patients also have problems distinguishing the yellow and yellow-green hues from caps 16 to 22 in box 1 but they score well in the red and green areas (see figure 2).

Deutans or so called green 'blind' (deuteranomalous or deuteranopic) have mid points between 56 and 61. Thus they have most confusion trying to distinguish between blue and bluish-purple caps in box 3. Deutan patients make a few errors with orange-yellow caps between 14 and 18 in box 1 and mostly normal responses in the green and red areas of the spectrum (see figure 2). As a result the graph of a typical protan patient has more 'horizontal' poles than that of a deutan patient.

Tritans or so called blue 'blind' (tritanomalous or tritanopic) have a mid point between 46 and 52 thus they have most problems distinguishing between the greenish-blue caps in box 3. They also make mistakes distinguishing the different red hues between the red caps 84 and 4 (boxes 4 and 1) hence the more 'vertical' appearance of the graph. Tritans typically have no trouble distinguishing pure blue hues or yellow hues thus score well in those areas of the graph (see figure 2).

Patients who have a generalised loss of colour vision (due to an advanced retinal disease for example) will show errors right around the spectrum (see figure 3).

The FM 100 hue test is the most comprehensive of the Farnsworth Munsell type tests giving both differential diagnosis and score (thus progression) of the disease. The test can be used to screen for any type of colour vision loss. The major disadvantages of the test are the time it takes especially when a patient has an acquired

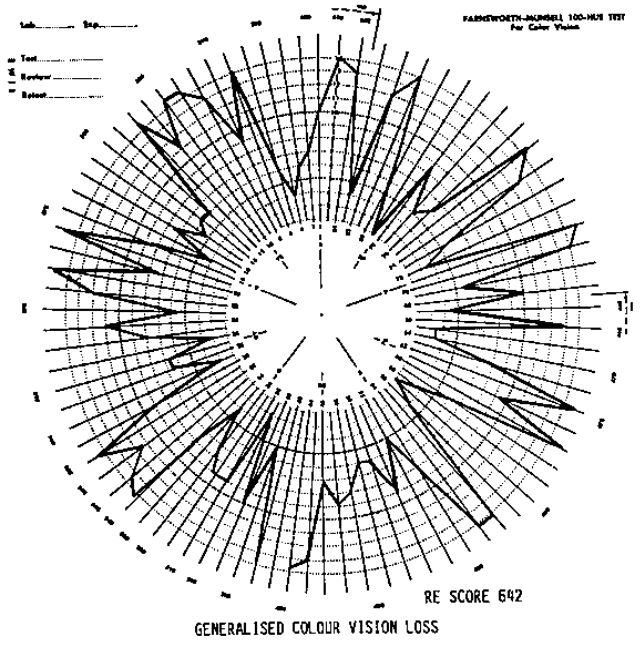

Figure 3: Generalised colour vision loss on the FM 100 hue test.

THE UNIVERSITY OF SYDNEY, DEPARTMENT OF CLINICAL OPHTHALMOLOGY
FARNSWORTH 15 HUE TEST

NAME SAMPLE RESULT AGE _____ SEX _____
DATE _____ HOSP. NO. _____

ANALYSIS

RED-GREEN DEFECT	DEUTERANOPE
YELLOW-BLUE DEFECT	TRITANOPE
PROTANOPE	NORMAL

RIGHT EYE	PATIENT ORDER	1	2	15	14	3	4	13	12	5	6	11	16	7	8	9
	CHIP NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LEFT EYE	PATIENT ORDER	1	15	14	13	2	3	12	11	4	5	10	9	6	7	8

DEUTERANOMALOUS
PROTANOMALOUS

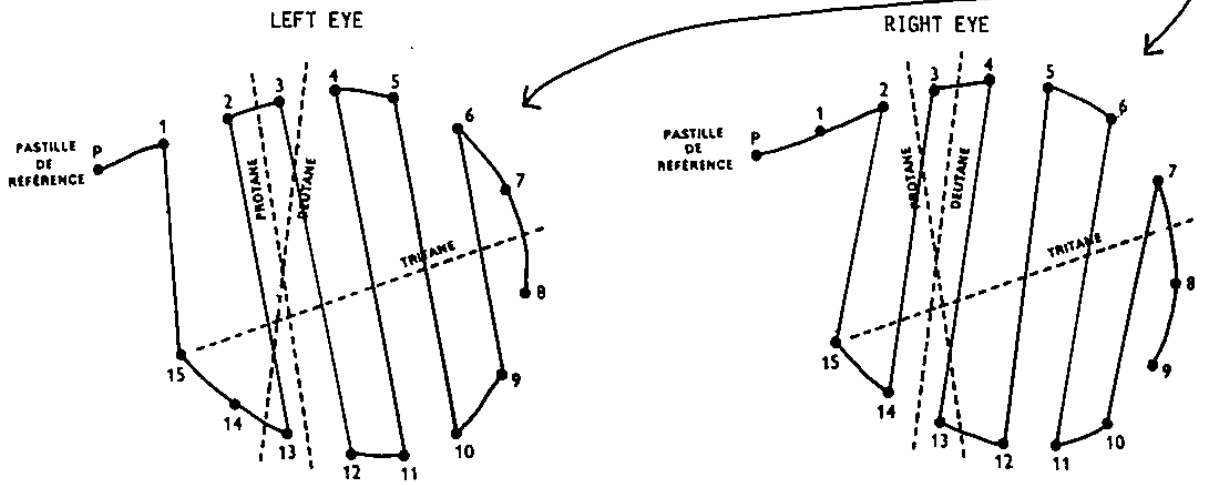

Figure 4: Axes of Confusion seen on the FM Panel D-15 test.

loss and thus must be tested monocularly. Also the differences between adjacent hues are so slight that some patients are frustrated by the fact that they cannot distinguish between them at all. Patients must be able to arrange the caps and thus must not have problems with the concept of ordering the colours into a natural colour sequence.

FARNSWORTH MUNSELL PANEL D-15 (FM D-15)

This test's full name is the Dichotomous Test[5] although it is commonly known as the FM Panel D-15. It was so named because to a colour defective patient the colour circle is virtually cut into two halves along an axis of confusion, (dichotomous means cut into two halves). For deutan patients this axis of confusion is the green to bluish red and for protan subjects it is along the bluish green to red diameter. For tritan patients the axis runs from yellow to blue. These axes are printed on the score sheet (see figure 4).

The FM D-15 test was not designed for screening. This was emphasised by a number of authors[4-6] including Linksz[5] who stated that "..the Farnsworth D-15 Test is not designed to separate colour normals from colour defectives. It is also not a test to separate the colour anomalous from the dichromat. It separates sufficiently affected deutans from sufficiently affected protans. It also separates sufficiently affected deutans and protans from those not seri-

ously affected once the *PRESENCE OF THE DEFECT* has been established by *SOME OTHER MEANS*". For example, a strongly affected deutan will confuse green plus yellow (which is lime green to normal observers) with red plus purple plus yellow (which is orange to normal observers). Both colours appear yellow to the deutan patient who is strongly affected. A mildly affected deutan patient will not confuse these colours on the FM D-15 test as the chroma (or saturation) used is strong enough to enable the patient to distinguish between the lime green and orange caps. Although the mild deutan patient perceives these two colours differently from the colours perceived by the normal observer the patient is able to distinguish between them.

The FM D-15 test consists of 15 loose caps and one fixed cap (the reference cap) in one box (all with Munsell value 5 and chroma 5). The hue of each cap has been chosen so that adjacent caps have approximately equal hue differences. When the caps are arranged in order out of their box they form a hue circle. As a result errors can be made across the hue circle (ie patients can place red caps next to green ones or blue caps next to yellow ones).

When doing the test the patient is instructed to arrange the caps in order in the box starting next to the fixed reference cap. Once completed the box is shut, inverted and reopened. A number is seen on the underside of each cap. The order in which the patient has arranged the caps is recorded on a score sheet (see figure 4). Starting at point 'P' the points on the hue circle on the score sheet are connected according to the order given by the patient.

Patients with a colour vision anomaly sufficient enough to affect their performance will make characteristic errors across the hue circle (see figure 4). For example protans or deutans frequently place the purple cap 15 next to the blue cap 1. They then continue to confuse the bluey greens and purples and so on. Tritans tend to confuse cap 7, a yellow-green with the purple cap 15 placing them side by side (see figure 5a).

Subjects with normal colour vision or mild anomalies that are not sufficient enough to affect their performance may make one or two minor errors such as reversing adjacent caps (see figure 5b and 5c). According to the manual their errors will not usually be across the hue circle or they may have only one error across the circle.[7] The major single error that can occur commonly in subjects with otherwise normal colour vision is placing cap 7 (green) next to cap 15 (purple) then caps 14, 13, 12, 11, 10, 9 and 8 (see figure 5d). This occurs because of the marked colour difference between caps 7 and 8; however, it is not considered to be indicative of colour vision anomaly.[6] Minor errors are reported to be common when testing young children.[8,9] In the author's experience such minor errors in those patients who have had a normal result in the screening tests such as the Ishihara warrant further investigation on the FM 100 hue test to rule out more marked colour vision anomaly.

The FM D-15 is designed to differentiate between those patients with congenital anomalous trichromatic colour vision whose daily tasks or work tasks will be affected by the abnormality from those who will not. According to the manual any patient with congenital anomalous trichromatic colour vision diagnosed by another test such as the Ishihara who has a normal result on the FM D-15 test should have almost no difficulty in performing most tasks in which colour vision is a factor.

The FM D-15 test is very portable, quick and easy to perform. As a result it is tempting to use it as a screening tool. However it must be remembered that it *must* be used in conjunction with another colour vision test as the FM D-15 is designed so that mildly affected colour defective patients will *pass*. It is also an effective test to use to monitor the effect of ageing on colour perception.[10]

CITY UNIVERSITY TEST

The City University test was derived from the FM D-15 for use with patients who have problems with the concept of sequencing or ordering needed to put the caps in the correct order in the FM D-15 box. The original aim of the test was to provide a version of the FM-D 15 which was more simple to perform.[11] Like the FM D-15,

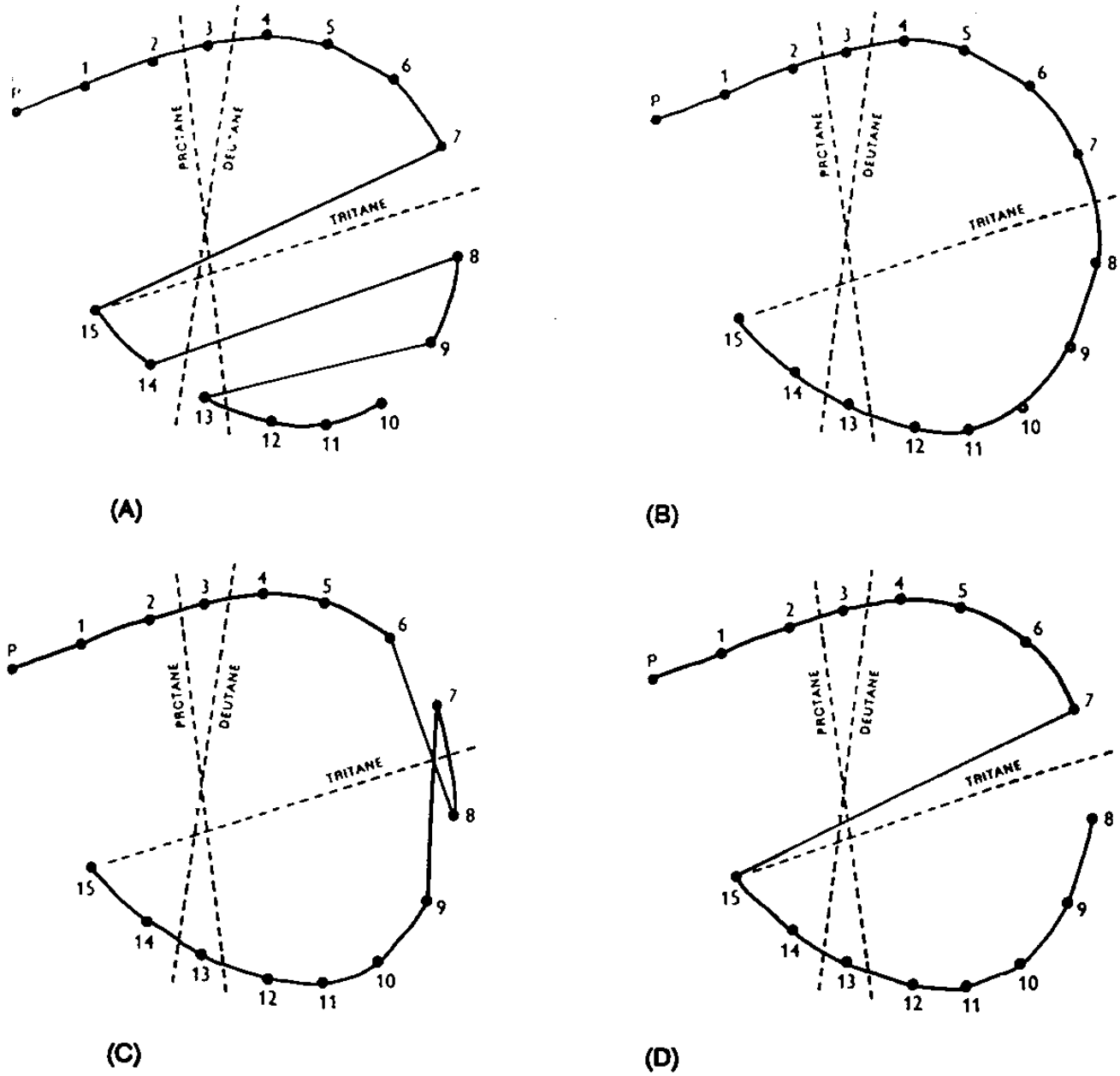

Figure 5: Characteristic error patterns seen on the FM Panel D-15 test; (a) Tritan defect, (b) normal result, (c) normal result with 2 reversals, (d) normal result with 1 major single error.

when used to test patients with congenital anomalous trichromatic colour vision, it distinguishes those who are likely to experience difficulty with their anomaly from those who are not. It was also designed to allow those with only a mild anomaly to 'pass' the test.

The 2nd edition (1980) of the test consists of 11 plates including a control plate. Each plate has one coloured spot in the centre, the central reference spot and 4 surrounding spots known as the comparison spots. Plate A is the control plate.

In each plate the patient is asked to look at the central reference spot and tell the examiner which of the comparison spots is most similar in colour to the central reference spot.

CITY UNIVERSITY COLOUR VISION TEST (2nd Ed. 1980)

Address ..... Patient .....

Examiner ..... Male/Female Date 24 / 11 /1989

Spectacles worn? YES/NO RE/LE/BE

Illumination (Daylight) Type ..... level .....

FORMULA: Here are 4 colour spots surrounding one in the centre. Tell me which spot looks most near in *colour* to the one in the centre. Use the words "TOP", "BOTTOM", "RIGHT" or "LEFT". Please do not touch the pages.

	PAGE (A is for demonstration)	SUBJECT'S CHOICE OF MATCH R	L	Both	NORMAL	DIAGNOSIS PROTAN	DEUTAN	TRITAN
"CHROMA FOUR"	1			R	B	R	L	T
	2			B	R	B	L	T
	3			T	L	R	T	B
	4			L	R	L	B	T
	5			L	L	T	B	R
	6			L	B	L	T	R
"CHROMA TWO"	7			T	L	T	R	B
	8			L	R	L	B	T
	9			L	B	L	T	R
	10			B	T	B	L	R
SCORE	AT CHROMA FOUR				1/6	4/6	1/6	/6
	AT CHROMA TWO				/4	4/4	/4	/4
	OVERALL				1/10	8/10	1/10	/10

Probable type of Daltonism P; PA, EPA MIXED
D, DA, EDA
TRITAN

Figure 6: City University test score sheet.

The patient's responses (ie the comparison spot to the right R, left L, top T, or bottom B) are recorded on the score sheet provided with the test (see figure 6). If most errors fall in the protan column, for example, then the patient has a protan defect.

According to the test manual, two errors, particularly in plates 7 to 10, suggests that the subject is on the borderline of being handicapped by his/her colour vision anomaly.[12] Errors on 3 or more plates indicates an "unsafe" degree of colour vision deficiency.

In plate A and plates 1 to 6 the coloured spots are 8mm in diameter which subtend 1.5° when viewed at 35cms. Plates A and 1,2,4,5 and 6 contain the same Munsell hues as the FM D-15 with the Munsell value 5 and chroma 5. Plate 3 contains two additional comparison hues with Munsell value 5 and chroma 5.

In plates 7 to 10 the spots are 4mm in diameter and subtend 0.6°. In these plates the Munsell hues are desaturated with Munsell chroma 2. (Munsell value 5 remains the same).

In the second edition of the City University test the control plate (plate A) has a green centre spot which is identical to cap 6 in the FM D-15. The correct comparison spot is the one that is the SAME hue as the reference spot thus is also identical to cap 6 in the FM D-15. It sits directly below the central reference spot. The remaining three comparison spots are all the same purplish hue which is identical to cap 13 in the FM D-15 test. This is designed so that patients with anomalous colour vision can and should respond correctly on this plate. If the patient makes an error or does not respond to this plate there is no point in continuing with the test as the patient is either malingering or their vision is too poor to do the test.

In the remainder of the plates the correct answer is the comparison spot that is the adjacent hue to the central reference spot hue. For example in plate 1, the central reference spot is identical to FM D-15 test cap '14', and the comparison spot below it is identical to FM D-15 test cap '13' which sits adjacent to cap '14' when the FM D-15 caps are placed in the correct order in the box. The normal subject would thus choose the bottom comparison spot (B).

The three remaining comparison spots are chosen from the opposite side of the hue circle and in plate 1 they are the same hues as caps '1', '3' and '8' in the FM D-15. (All these caps are from the other end of the box when the FM D-15 caps are placed in the correct order.)

Thus a patient with a protan defect would choose the comparison spot on the right (R) which is equivalent to the FM D-15 cap 1; a deutan patient would choose the comparison spot on the left (L) which is equivalent to the FM D-15 cap 3 and a tritan patient would choose the comparison spot on top (T) which is equivalent to the FM D-15 cap 8.

As these three remaining spots are comprised of hues from the FM D-15 that represent the most isochromatic confusion for protan, deutan and tritan patients a characteristically incorrect response is given by patients with anomalous colour vision.

When used to evaluate colour vision anomaly

on patients who fail one of the tests designed to test for congenital anomalous trichromatic colour vision, (such as the Ishihara), patients who subsequently pass the City University test have a slight colour vision defect which is not likely to affect their performance in everyday tasks. Those who fail the Ishihara and have between one and 5 errors on the City University test have a moderate colour vision defect and those with more than 5 errors on the City University test can be considered to have a more severe colour vision loss.[12,13]

One criticism of the City University test is that the small targets in the diagnostic plates (plates 7 to 10) make them extremely vulnerable to false positive results thus mixed protan deutan diagnostic responses occur as an artifact of the test format.[11] The targets often give false positives for a tritan defect.

Neither the 1st nor 2nd edition of the City University test, like the FM D-15 test they were derived from, were designed to be used for screening.[11-13] In a study in 1984 Birch[11] tested patients with known colour defects including 64 patients with congenital anomalous trichromatic colour vision and 166 eyes with acquired colour blindness (secondary to diabetes). She reported that neither edition of the test was effective for colour vision *screening*. Her study concluded that the City University test can be used in a test battery to provide information about the severity of the colour defect if a test format other than the FM D-15 is necessary.

A situation where a test other than the FM D-15 was needed to assess colour vision was reported recently in a paper presented by Deveraux,[14] who reported on a population of young adult under achievers learning to use computers. Colour vision assessment with the FM D-15 was not possible in a number of cases as the subjects could not manage the concept of ordering the colours in the natural colour sequence. In every case the subjects were able to perform the City University test.

Just like the FM D-15 test the City University test is quick and easy to perform but it has the added advantage of being able to be used on patients who have problems with ordering the colours into the correct sequence. Once again it is tempting to use the City University test for screening but it should only be used in conjunction with one of the other colour vision tests.

LANTHONY'S DESATURATED D-15 TEST

This test was designed to be used in conjunction with the FM D-15 test; however, it can be used independently as part of the colour vision test 'battery'. The test is performed and is scored in exactly the same way as the FM D-15 test with the caps in each being exactly the same hues as those used in the FM D-15 test. The only difference is that Lanthony's Desaturated test uses lower chroma (less saturated) hue caps than the FM D-15. The chroma is reduced to 2 on the Munsell scale and the value (the proportion of black and white) is increased to 8. As a result there is exactly the same difference between adjacent caps in the desaturated D-15 and the normal FM D-15 but it is more difficult to distinguish between the hues.[15]

If a colour vision abnormality is found when using one or the other colour vision tests the Lanthony's Desaturated test will establish whether or not the defect is likely to affect the patient. As previously stated when a patient is found to have a colour vision defect on one of the other colour vision tests which does not show up on the FM D-15 test it is considered that they are unlikely to be handicapped by their disturbance in colour vision. If a patient with the colour vision abnormality has a normal result on the Lanthony's Desaturated test as well as the FM D-15 test it is extremely unlikely to affect their performance in colour related tasks. Alternately a defect may be apparent on the Lanthony's D-15 test which is not apparent on the FM D-15 test. This adds a further classification to those only mildly affected by their defect.

As the Lanthony's Desaturated test is more sensitive than the FM D-15 it may be used to detect abnormalities in colour vision which are very mild thus not apparent on the FM D-15 test. It may also be used to follow the progression of acquired colour vision loss. One author has reported that the Lanthony's Desaturated test is

more sensitive in detecting deterioration in colour discrimination associated with increasing age.[10]

Once again clinicians should be reminded that this test alone is not a screening test for colour vision abnormalities.

ROTH 28 HUE TEST

This test consists of 28 different hue caps. It was designed to overcome the shortcomings of the FM D-15 and the FM 100 hue; namely that the FM D-15 test has a large variation in hue around the circle so it is not very sensitive to overall diminution of differential shade perception[16] and the FM 100 hue test is very time consuming. The FM 100 hue test provides a better quantitative estimation of colour vision deficiencies than the Roth 28 hue test. However the FM 100 hue test is very time consuming, especially when testing monocularly for acquired colour vision defects and, as the closeness of the hue shades used can prove difficult to some normal subjects, the Roth 28 hue test was designed to be used in its place.

The Roth 28 hue test is made up of every third cap from the 100 hue test (1,4,7,10....82) and the numbers underneath the caps have not been altered. Cap number one is used as the reference cap and the other 27 are arranged in order of successive shades in the one box.

The order that the patient places the caps in the box is plotted directly on to a score sheet graph (see figure 7). Each hue is represented on the graph in the same position as it is on the FM 100 hue test graph. Like the FM D-15 test errors may be made across the colour circle as all the caps are presented to the patient from the one box. On average it takes between 2 and 3 minutes to do the test (per eye).

Results may be normal (in which case the plot looks like a circle) or minor errors can occur, for example reversing adjacent caps. Such errors are said to be insignificant unless they are clustered in one particular area. When abnormalities are present the lines joining the cap numbers cross the hue circle. Like the FM D-15 test these lines may be parallel to the deutan, protan or tritan axes depending on the type of anomaly present (see figure 7).

The Roth 28 hue test also has 2 other axes; tetaran and scotopique. Lines are parallel to the tetaran axis when the patient has an extremely rare acquired colour vision anomaly known as tetaranopia. This is a type of blue yellow colour blindness in which blue and yellow are confused and red and green are not. This differs from other forms of blue yellow 'blindness' where red and green are confused and blue and yellow are not.

If colour vision testing is performed in scotopic conditions responses are parallel to the scotopique axis. This may also occur when a patient has total achromatopsia (ie totally colour blind) or alternately the responses from such patients may be totally confused. (The term scotopique suggests scotopic or rod vision only).

The main problem with the Roth 28 hue test is that sometimes the first cap put into the box may be incorrect. The patient will then arrange

UNIVERSITY OF SYDNEY, DEPT. CLINICAL OPHTHALMOLOGY

ROTH 28 HUE TEST SCORE SHEET

NAME:_____ HOSP NO:_____

AGE/DOB:_____ SEX:_____

DATE TESTED:_____

RIGHT EYE: 1 82 79 76 40 43 73 46 49 70
67 52 55 61 64 58 37 34 31 4
28 25 7 22 10 19 13 16 - DEUTAN

LEFT EYE 82 1 4 7 10 13 19 16 22 25
28 31 34 37 40 43 46 49 79 52
76 55 73 58 67 61 64 70 - PROTAN

LEFT RIGHT

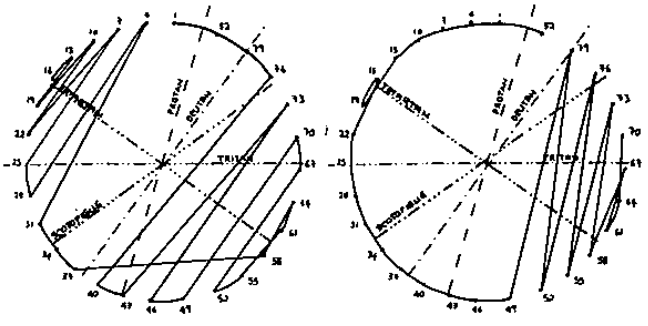

Figure 7: Roth 28 hue test score sheet.

the next couple of caps incorrectly then returns to normal. This will result in a few responses being parallel to an axis of abnormality in a patient with normal colour vision. Its advantages are that it is easier to do than the FM 100 hue test and it is reported to be less confusing then the FM D-15 test.

The literature reviewed suggests that this test should not be used in isolation for screening; however, it can be used in conjunction with other colour vision tests for screening.[17] (In practice the Roth 28 hue test can be used in isolation in cases of suspected congenital anomalous trichromatic colour vision; however, like the FM D-15, very mild cases can 'pass' the Roth 28 hue test.)

In the case of a suspected acquired colour vision abnormality the Roth 28 hue test may be used for screening; however, if a defect is found it should be followed by a FM 100 hue test to quantify the defect so that the defect can be monitored for future progression. The test can also be used to differentially diagnose between colour vision anomalies.

FARNSWORTH F2 TRITANOPIC PLATE

This test consists of a single pseudoisochromatic plate (ie plates such as those used in the Ishihara test). The background spots are light mauve in colour and there are 2 overlapping squares superimposed on the background in the same manner as the numbers on the background in the Ishihara test. To the normal observer one square is yellow-green and the other is blue. The tritan patient sees only the blue square.

This is the only one of the FM tests mentioned that does not test the patient's ability to discriminate between hues. It can be used as a screening test for a tritanopic defect.

CONCLUSIONS

When testing for possible colour vision anomalies clinicians generally want to screen for defects, diagnose the type of defect present and grade (or score) the severity of the defect. Unfortunately, with the exception of the FM 100 hue test, no individual Farnsworth type test can fulfil all three requirements. Although the FM 100 hue test will perform the task of screening it is extremely impractical as it is so time consuming, especially when testing must be performed monocularly when an acquired defect is suspected.

When attempting to screen for colour vision defects possible congenital defects must be separated from possible acquired defects.

(a) Acquired defects

When patients complain of symptoms such as altered colour perception, desaturated appearance of colours, reduced visual acuity (without adequate explanation), central visual field loss, or when the patient is taking certain drugs or toxic substances or if there are any other observations which may be associated with altered colour vision *acquired* colour vision loss would be suspected.

In such a case the FM 100 hue test (performed monocularly) is the most appropriate. The Roth 28 hue test which is a less time consuming alternative will usually reveal an acquired defect but it does not give an exact score. (If the Roth 28 is performed first and the result is normal a FM 100 Hue test should be performed.)

Alternately the FM D-15 test, City University test or the Lanthony Desaturated D-15 may be performed as a starting point but it must be emphasised that if the results on these tests are normal further investigation *must* be carried out.

If a defect is found on any test a FM 100 hue test must be performed *if* the severity of the defect is to be graded. This is most important as acquired defects may be progressive passing through trichromatic, dichromatic to a monochromatic stage. The FM 100 hue test is the only one of the Farnsworth type tests to give a quantitative assessment of the defect and thus can be used to assess the effect of treatment in some instances.

With the exception of the Hardy Rand Rittler test (HRR) *none* of the pseudoisochromatic tests (ie Ishihara, Guys, Matsubara, SPP etc) tests are appropriate to test for acquired colour vision defects. These tests were designed to test for *congenital* red green colour 'blindness' (ie anomalous trichromatic colour vision).

(b) Congenital defect

When screening for *congenital* anomalous trichromatic colour vision which affects up to 8% of males and 0.4% of females, the pseudoisochromatic tests such as the Ishihara or, alternately, the anomaloscope tests are generally the most appropriate as they are quick and easy to use. If an abnormality is found it can be classified into protanomaly or deuteranomaly by the pseudoisochromatic tests. It can be roughly graded into mild, moderate or severe using the FM D-15 test, the City University test or the Lanthony Desaturated D15 test. Exact quantitative grading can be given by the FM 100 hue test but this is probably unnecessary as the condition is non progressive. Testing for suspected congenital anomalous trichromatic colour vision can be done binocularly to save time as the condition is usually bilateral and symmetrical.

Very rarely cases of suspected congenital anomalous trichromatic colour vision are not found on the pseudoisochromatic tests. In such cases the FM 100 Hue or an anomaloscope test should be performed. (Anomaloscopes can be used as a quick, easy and effective screening test for congenital or acquired colour vision loss; however, as they are so expensive they are rarely available in clinics.)

With the exception of anomaloscopes there is no individual quick and easy test that will screen for both congenital and acquired colour vision loss giving a differential diagnosis and a qualitative assessment. As a result a battery of tests may be necessary using a 'less sophisticated' test to find a defect then a more 'sophisticated' (and usually more time consuming) test to evaluate it. However it is imperative that the appropriate battery of tests be used, especially when initially screening.

References

1. Peyman G, Sanders D, Goldberg M. Colour vision. In Part 4, Clinical Physiology of the Retina; Principles and Practice of Ophthalmology. W.B Saunders Co. Philadelphia 1980; 2:4; 846-848.
2. Farnsworth D. The Farnsworth Munsell 100 Hue test for colour discrimination. Instruction Manual. Luneau Ophthalmologie, Paris 1976: 1-6.
3. Birch J, Chisolm I, Kinnear P, Pinckers A, Pokorny J, Smith V, Verriest G. Ch 5, Clinical testing methods. In Pokorny J, Smith V, Verriest G, Pinckers A, eds. Congenital and Acquired Colour Vision Defects. Grune and Stratton, New York 1979: 94-95.
4. Adams J, Spivey B. Colour vision. In Biomedical Foundations of Ophthalmology. 1982; Ch 19 Vol2: 1-25.
5. Linksz A. Ch XVI. Instructions for the proper handling of the FM D-15 test. In Linksz A. An Essay on Colour Vision. Grune and Stratton, New York, 1964: 212-213.
6. Birch J, Chisolm I, Kinnear P, Pinckers A, Pokorny J, Smith V, Verriest G. Ch 5, Clinical testing methods. In: Pokorny J, Smith V, Verriest G, Pinckers A, eds. Congenital and Acquired Colour Vision Defects. Grune and Stratton, New York 1979: 97-98.
7. The Farnsworth Panel D-15 Manual. Luneau Ophthalmic, 1972: 2.
8. Adams A, Ballet R, McAdams M. Colour vision; blue deficiency in children? Invest Ophthalmol and Vis Sci, 1975; 14; 8: 620-625.
9. Cohen J. Diagnosis of colour vision deficiencies in learning-disabled children. In Karger and Basel eds. Colour Vision Deficiencies III. Modern Problems in Ophthalmology, 1975; 17: 364-367.
10. Bowman K, Collins M, Henry C. The effect of age on the performance of the panel D-15 and the desaturated D15: a quantitative evaluation. Verriest G ed. Colour Vision Deficiencies VII. Dr W Junk, The Hague, 1984; 227-231.
11. Birch J. The contribution of the City University Test (lst and 2nd editions) in a clinical laboratory setting. In Verriest G. ed. Colour Vision Deficiencies VII. Dr W Junk Publishers, The Hague. 1984: 193-198.
12. Fletcher R. The City University colour vision test, 2nd edition. Keeler Instruments, London, 1980.
13. Fletcher R. A modified D 15 test. Mod Probl Ophthalmol 1972; 11: 22-24.
14. Deveraux K, Crisp G. Visual display terminals and visual function; a pilot study. Paper presented at the 46th Annual Scientific Conference of the OAA, Brisbane, Sept 1989.
15. Lanthony's Desaturated 15 Hue Test according to Farnsworth; Manual. Luneau Ophthalmologie.
16. The Roth 28 hue test according to Farnsworth. Luneau Ophthalmologie, Paris
17. Neubauer O. Comparing methods of examination in acquired colour vision deficiencies. Modern Problems in Ophthalmol., Acquired Colour Vision Deficiencies, Vol 11; 19-21, 1972.