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ORIGINAL INVESTIGATION

Can Protanopia Be Correctly Diagnosed in Clinical Practice? An Evaluation of Diagnosis by Four Screening Tests

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ABSTRACT

Significance. Protanopia is a color vision deficiency (CVD) which is unacceptable for certain occupations. This study compares simultaneously for the first time the ability of 3 recently revised or developed clinical tests of color vision with the Ishihara test to diagnose protanopia from other color vision deficiencies. **Purpose.** The objectives were to examine the ability of 4 clinical tests to differentiate (1) between protan and deutan CVDs in patients with protanopia and deuteranopia, and (2) protanopes and deuteranopes as "strong" deficiencies. **Methods.** The Hardy Rand & Rittler (4^{th} ed.), City University (3^{rd} ed.), Ishihara and Mollon Reffin tests were evaluated against the Oculus HMC anomaloscope for 18 protanopes and 9 deuteranopes. Diagnosis by anomaloscopy was subsequent to administration of screening tests. **Results.** The Ishihara test misdiagnosed all 18 protanopes as having a deutan deficiency. By contrast the HRR and Mollon Reffin tests correctly identified protan CVD in 100% of protanopes. No screening test was able to reliably diagnose protanopia on the basis of a strong protan CVD. **Conclusions.** The Ishihara test is not suitable for screening for protanopia; its failure to diagnose protanopes as having a protan CVD was far greater than in previous studies. The Hardy Rand & Rittler and Mollon Reffin are the most reliable tests for this purpose. None of the screening tests was able to reliably differentiate dichromacy from strongly anomalous trichromacy.

In common with other inherited red-green color vision deficiencies, protanopia and deuteranopia have been shown to be due to abnormal cone pigment. Specifically, protanopia and deuteranopia are associated respectively with absence of long-wave-sensitive and medium-wave sensitive cone pigment.[1] While both types of color vision deficiency cause significant problems for color discrimination, protanopia in particular would be expected to result in reduced ability to detect red signal lights and has been demonstrated both on land[2,3] and at sea.[4] Several reports have suggested that protanopes should be excluded from occupations in which red signal lights or warning signs are used.[5,6] The occupational significance of colour vision deficiencies generally has been summarized by Cole.[7]

In cases where it is important for occupational reasons to detect patients with protanopia or strong protanomaly, the question arises as to how effectively they can be differentiated from deuteranopia/strong deuteranomaly. The method of choice is generally regarded as use of an anomaloscope with Rayleigh color matching of red plus green color mixtures against a yellow comparison stimulus.[8] However, such instruments are expensive and time-consuming to administer, and generally not available in clinical practice. It would therefore be of value for clinicians to be able to reliably differentiate between protan and deutan using simpler screening tests which are more amenable to clinical and occupational use, and also differentiate between protanopia and strong protanomaly.

Among the more popular color vision deficiency screening tests are: the Ishihara (Kanehara Trading, Tokyo, Japan; commonly used for occupational screening), the Hardy Rand and Rittler 4th edition (Richmond Optical, CA), and the City University 3rd ed. (Keeler USA, Malvern, PA). The fourth test we used was the Mollon Reffin Minimalist (Mollon Reffin test; PA Vision, Margate, Kent, UK). The Hardy Rand & Rittler has been re-engineered

colorimetrically relative to previous editions and shown to have significant merit.[9,10] The City University test[11] has been significantly changed in its third edition to include a series of screening plates but fewer "detection/selection" plates, but has not been fully validated. The Mollon Reffin test test[12] has been shown to be suitable for young children[13] as well as adults but, although used and validated for acquired color vision deficiencies,[14] its predictive validity for inherited color vision deficiencies has yet to be fully investigated.

The Ishihara, Hardy Rand and Rittler, City University test, and Mollon Reffin test tests have not been simultaneously evaluated before in comparison to the anomaloscope for inherited color vision deficiencies with the result that their relative predictive efficacy cannot be compared, though the Ishihara, Hardy Rand and Rittler and anomaloscope have been compared for detection of optic neuropathy.[15] The ability of the Ishihara to reliably discriminate between protan and deutan color vision deficiencies has long been questioned.[16-20]

The objectives of the present study were (1) to assess the abilty of the 4 screening tests to differentiate between protan and deutan color vision deficiencies, which are potentially confusable using screening tests and (2) to assess whether protanopia and deuteranopia can be differentiated from protanomaly and deuteranomaly in clinical practice. While the second objective is often of less importance in a screening context, should any screening test be able to successfully make such a diagnosis it would save clinicians from needing to refer some patients to a color vision specialist; this was one objective of redesigning the fourth edition of the Hardy Rand and Rittler test.[9] Further, it would be a useful feature of a screening test if it provides a useful quantification of the severity of color vision deficiencies. For example the

number of mistakes on the Ishihara test has been reported to be a poor index of severity of color vision deficiencies.[7]

METHODS

Eighteen consecutive patients with protanopia were selected from patients attending the Colour Vision Assessment Unit (CVAU) of the National Optometry Centre, Technological University Dublin. Nine consecutive deuteranopes were selected. All 27 patients were referred to the CVAU as a result of failure on the Ishihara test or because of suspected color vision deficiency based on patients' symptoms or online color vision deficiency test results. All screening tests were performed before anomaloscopy such that the patients' definitive color vision deficiency type was unknown at the time of performing screening tests. All patients (or an accompanying parent or guardian) signed an informed consent form conforming to the Declaration of Helsinki. Data storage conformed to General Data Protection Regulations in Ireland. Protanopic patients ranged in age from 9 to 40, and were predominantly male (17 males, 1 female; mean 17.3 years) while deuteranopes ages ranged from 11 to 50 (9 males, mean 28.0 years).

All patients were assessed with the 2005 edition of the 24 plate Ishihara test, the Hardy Rand and Rittler, and City University test. 11 patients were also examined with the Mollon Reffin test when available; this uses Munsell test samples of increasing saturation along protan, deutan and tritan confusion axes. Illumination for the screening tests was provided by color corrected fluorescent lighting from a desk lamp using a pair of 15W 46 cm lamps (PL desk lamp, The Daylight Co., Spring, Texas) with a stated color temperature of 6000 degrees Kelvin. Tests were viewed against a dark background. Illuminance at the plane of the test plates was 659 lux using a PMA 2100 meter (Solar Light Company, Orlando, FA). All tests

were administered at the manufacturer's recommended viewing distance. All test plates were oriented at approximately 45 degrees to the illumination and orthogonal to the viewing axis. Viewing time for test plates was restricted to 4 seconds. All test plates and targets were clean; tests were kept in the dark when not in use. Patient exclusion criteria were: near visual acuity worse than N6, self-reported treatment for eye diseases.

The Oculus Heidelberg Multi Color (HMC) anomaloscope[21] (Oculus GmbH, Wetzlar, Germany) was used with Rayleigh matching using a similar protocol to that described in a previous study in which Moreland matching was used.[22] In brief: the instrument was used in Manual Mode (with no preselection of color vision deficiency type), no pre-adaptation was used in order to avoid after-images, and patients were allowed to practice making matches with both controls using a method of adjustment bracketing technique. This was followed by adjustment by the patient of the luminance of the yellow stimulus only, again using a bracketing technique, to determine whether or not a match could be made to specific red plus green mixtures set by the examiner to determine the range of the patient's matches. Yellow brightness matches were repeated for specific red/green mixtures when necessary. The anomaloscope was used in the present study as the benchmark against which the screening tests were evaluated.

Protanopia was defined on the basis of both (a) a complete range of anomaloscope matches from 0 (monochromatic green: 545 nm) to 73 (monochromatic red: 666 nm), and (b) reduced luminance of monochromatic yellow (589 nm) to match monochromatic red (<=8 units) compared to normal. Deuteranopia was defined on the basis of both (a) a complete range of anomaloscope matches from 0 to 73, and (b) normal luminance of monochromatic yellow to match monochromatic red.[21]

Classification of color vision deficiency severity on the screening tests was as follows: City University test - number of protan or deutan choices as appropriate from plates 5 to 10; Hardy Rand and Rittler - number of protan or deutan choices as appropriate from plates 11 to 20; Ishihara - classified as strong or mild on plates 16 & 17; Mollon Reffin test - thresholds obtained on protan and deutan axes.

RESULTS

Protan/Deutan Diagnosis

All screening tests correctly diagnosed all deuteranopes as having deutan color vision deficiency (see Table 1, in which screening test classification of protan or deutan deficiency is reported for patients who were subsequently diagnosed with the anomaloscope to be deuteranopes).

However, only the Hardy Rand and Rittler and Mollon Reffin tests achieved 100% protan diagnosis for protanopes (see Table 2). 78% of protanopes were correctly diagnosed as protans using the City University test: in 2 cases protanopia was misdiagnosed as deutan deficiency and in 2 further cases equal responses for protan and deutan were obtained. However there is overlap of the 95% confidence limits of frequency of protan classification between the City University and the Hardy Rand and Rittler and Mollon Reffin tests. Although the Ishihara correctly diagnosed all deuteranopes as being deutan, it misdiagnosed all protanopes as deutan.

Diagnostic outcomes are presented in Table 3 for protanopes and deuteranopes combined; outcomes for deuteranopes have been weighted by a factor of two to avoid bias caused by unequal sample sizes for deuteranopes relative to protanopes with the result that there are

now 18 deuteranopes. The Hardy Rand and Rittler and the Mollon Reffin test both achieved 100% correct diagnosis. The City University test was less successful, achieving 89% correct diagnosis; using our criterion of 5 or more plates as indicative of a "strong" color vision deficiency resulted in just a marginal overlap of confidence limits, while using 4 or more plates as the criterion was more successful. The Ishihara achieved only 50% correct diagnosis, this figure being entirely due to correct diagnosis of deutan color vision deficiency of deuteranopes. The proportions for City University test and Ishihara without weighting are respectively 85% and 33%. Proportions for Hardy Rand and Rittler and Mollon Reffin tests are unchanged at 100%.

Dichromatic/Anomalous Trichromatic Diagnosis

The Hardy Rand and Rittler classifies the strength of deutan and protan color vision deficiencies as being mild, medium or strong based on responses to 10 plates while the Ishihara test provides classification as either mild or strong based on just two plates. Since dichromatism implies a strong color vision deficiency, we compared the abilities of the HRR, Ishihara and City University test to predict dichromatism in Table 4. We used two criteria for the City University test: firstly we defined "strong" as being 4 or more deutan or protan responses out of a maximum possible 6 on the classification plates, and secondly 5 or more responses.

Table 4 shows the severity classifications from each test for protanopes and deuteranopes in separate columns. Ideally all four screening tests would indicate a "strong" deficiency, however defined, for all dichromats. Although protanopes were in all cases misdiagnosed as deutan by the Ishihara test (Table 2), Table 4 shows that the Ishihara was the most successful test for diagnosing possible dichromacy: 100% of patients were diagnosed as strong for both

protanopia and deuteranopia using plates 16 and 17, as distinct from the number of mistakes on the other plates. The Hardy Rand and Rittler was the next most successful for protanopes, while the City University test was least successful. The index of severity for the Mollon Reffin test was the patient's saturation threshold. Mean values were 5.8 (maximum possible is 6) for protanopes and 5.2 (maximum possible is 7) for deuteranopes.

Raw data for deuteranopes and protanopes are presented in Appendices 1 and 2 respectively. Captions are common to both and are presented in Appendix 3 (all three appendices are available at **[LWW insert link]**).

DISCUSSION

While direct comparison of the Ishihara and Hardy Rand Rittler (4th ed.) tests has been reported in one previous study,[10] the other two screening tests used in the present study (City University and Mollon Reffin) have not been evaluated before for inherited color vision deficiencies. The present study therefore provides a possible basis for selection of modern color vision screening tests by eye-care professionals.

Our finding that the Ishihara test misdiagnosed all 18 protanopes as being deutan was unexpected. To verify that this finding was not due to either the Ishihara test version used or the illumination, two protanopes were retested as follows: (a) on the same copy of the Ishihara test, (b) on a different (1998) edition of the 24 plate test, (c) on the 38 plate version, and (d) using tungsten illumination. For both patients and for all retest conditions the classification confirmed deutan deficiency. The complete failure of the Ishihara test to diagnose protanopes as having a protan color vision deficiency (all being diagnosed with a deutan deficiency) has not been reported before to the authors' knowledge and needs to be

checked in an independent study, but we note that protan/deutan differentiation has been found previously to be less successful for protans than deutans using the Ishihara test.[17,20] All of the protanopes in our study were able to see one number on each of the diagnostic plates 16 and 17, contrary to some previous reports.[18,20]

The differing protan/deutan predictive ability of the Ishihara diagnostic plates compared to the other three screening tests is also unexpected in that all four tests make use of the different chromaticity confusion axes for protan and deutan deficiencies passing through the desaturated/neutral points. These differences may be due to differences in the colorimetric properties of the dyes with which the tests are printed.[23] Illumination of tests in the present study was at 6,000 ^{0}K rather than at 6,500 ^{0}K of CIE standard illuminants C. Differences in the color rendering properties of illuminants may affect comparisons between different tests in different studies, though the Hardy Rand and Rittler test has been shown to be relatively resistant to this factor.[24] If the present finding is confirmed, it would present a serious drawback with the Ishihara test for occupational color vision screening where the type of color vision deficiency is important. The reason for using the 24 plate rather than the 38 plate version in the present study was simply that this is believed to be the more commonly used version in clinical and occupational health practices. It should be noted that the number of protanopes exceeded that of deuteranopes in our study simply because more protanopes presented themselves for assessment in the CVAU clinic.

In relation to the protan/deutan diagnosis on the Hardy Rand and Rittler, in the present study all 18 protanopes and all 9 deuteranopes were correctly diagnosed, in agreement with Bailey et al[8] who reported correct diagnosis of 5 protanopes and 4 deuteranopes. Cole et al. 2006[9] reported a lower predictive efficacy of 86% for classification into protan and deutan groups:

however their patient sample contained only 8 protanopes and 11 deuteranopes. Combining the results for the Hardy Rand and Rittler from the 2 previous studies with our own data results in 97% correct diagnosis of protan deficiency among protanopes and 100% correct diagnosis of deutan deficiency in deuteranopes. In the present study the City University test was less successful than either the Hardy Rand and Rittler or the Mollon Reffin test in correctly identifying protanopic patients as protan (78% compared to 100%).

In terms of prediction of dichromacy as distinct from anomalous trichromatism, one aim of the redesign of the HRR fourth edition was that dichromats would be differentiated by always showing a "strong" extent of color vision deficiency. Bailey et al.[9] reported that all 9 dichromats were correctly diagnosed as strong, whereas in the present study only 13 of 18 (72 %) protanopes and 6 of 9 (67%) deuteranopes were categorized as strong on the Hardy Rand and Rittler. The equivalent figures reported by Cole et al[10] was 3 of 8 (38%) for protanopes and 9 of 11 (82%) for deuteranopes. Combining the results for the Hardy Rand and Rittler from the 2 previous studies with our own data results in 68% for protanopes and 79% for deuteranopes.

It can be expected that the outcomes of the present study are applicable to other mainly White populations since a recent study using the Hardy Rand and Rittler found a 7% color vision deficiency prevalence among male school children in Ireland[25]; this is similar to values reported in other similar populations.[26]

The present data suggest that the Hardy Rand and Rittler and Mollon Reffin tests have 100% diagnostic efficacy and are the most effective of the 4 tests studied in identifying protanopes as being protans rather than deutans. The 2005 edition of the 24 plate Ishihara test was unable

to identify any protanope as having a protan deficiency although it did correctly diagnose all deuteranopes as being deutan. These conclusions have significance for protan/deutan diagnosis in occupations where this distinction is potentially important, such as pilots, emergency vehicle drivers and mariners.[7]

Our findings suggest that protanopia probably cannot be reliably distinguished from protanomaly using any of the four screening tests, confirming a previous report on the Hardy Rand and Rittler test[10], though deuteranopia probably can be more reliably distinguished from deuteranomaly. Where it is important to distinguish protanopia from strong a protan deficiency an anomaloscope is recommended. However, where this distinction is not important but it is necessary to screen protan patients for occupational reasons, the Hardy Rand Rittler test may be used to separate patients with a mild protan deficiency from those with either a moderate or strong extent. Alternatively a Mollon Reffin test threshold of 5 or worse on the protan axis may be used. However both conclusions should be evaluated further using a greater number of protanomalous patients than were available in the present study.

It would also be useful to extend the present study to include computer-based color vision deficiency tests. We suggest that ergonomics engineers should consider building in secondary cues in instrument and signal design such that color differences are reinforced by shape, position, flashing, size, auditory or other cues in order to assist color defective persons, particularly protans.

APPENDICES

Three appendices are included providing detailed results on the anomaloscope and 4 screening tests for 9 deuteranopes (Appendix 1) and 18 protanopes (Appendix 2). Appendix 3

contains explanatory material common to both Appendices 1 & 2. All are available at **[LWW insert link]**.

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Table 1. Comparison of Diagnostic Classification by Clinical Tests of Patients Diagnosed as Deuteranopes with the Anomaloscope.

		CU3 [n=9]	HRR4 [n=9]	Ishihara [n=9]	MR [n=6]
Protan	Frequency	0	0	0	0
	Percentage	0%	0%	0%	0%
	Confidence limits	0-33%	0-33%	0-33%	0-46%
Deutan	Frequency	9	9	9	6
	Percentage	100%	100%	100%	100%
	Confidence limits	66-100%	66-100%	66-100%	54-100%
Unclassified	Frequency	0	0	0	0
	Percentage	0%	0%	0%	0%
	Confidence limits	0-33%	0-33%	0-33%	0-46%

CU3: City University test, 3rd ed.; HRR4: Hardy Rand & Rittler test, 4th ed. ; MR: Mollon Reffin minimalist test. Confidence limits: binomial 95% limits for proportions.

Table 2. Comparison of Diagnostic Classification by Clinical Tests of Patients Diagnosed as Protanopes with the Anomaloscope.

		CU3 [n=18]	HRR4 [n=18]	Ishihara [n=18]	MR [n=11]
Protan	Frequency	14	18	0	11
	Percentage	78%	100%	0%	100%
	Confidence limits	52-94%	81-100%	0-19%	71-100%
Deutan	Frequency	2	0	18	0
	Percentage	11%	0%	100%	0%
	Confidence limits	1.0-35%	0-19%	81-100%	0-28%
Unclassified	Frequency	2	0	0	0
	Percentage	11%	0%	0%	0%
	Confidence limits	1.0-35%	0-19%	0-19%	0-28%

CU3: City University test, 3rd ed.; HRR4: Hardy Rand & Rittler test, 4th ed. ; MR: Mollon Reffin minimalist test. Confidence limits: binomial 95% limits for proportions.

Table 3. Diagnostic Outcomes for Protanopes and Deuteranopes Combined.

Diagnosis		CU3 [n=36]	HRR4 [n=36]	Ishihara [n=36]
% Correct	Frequency	32	36	18
	Percentage	89%	100%	50%
	Confidence limits	73-97%	90-100%	33-67%
% Incorrect (including unclassified)	Frequency	15	0	18
	Percentage	11%	0%	50
	Confidence limits	3-26%	0-10%	33-67%

Number of deuteranopes and their diagnostic outcomes have been doubled.
CU3: City University test, 3rd ed.; HRR4: Hardy Rand & Rittler test, 4th ed. ; MR: Mollon Reffin minimalist test. Confidence limits: binomial 95% limits for proportions

Table 4. Proportions of Dichromatic Patients Recorded as Having “Strong” color vision deficiencies.

Test		Protanopes [n=18]	Deuteranopes [n=9]
HRR4	Frequency	13	6
	Percentage	72%	67%
	Confidence limits	47-90%	30-93%
Ishihara	Frequency	18	9
	Percentage	100%	100%
	Confidence limits	81-100%	66-100%
CU3 (strong>=4 plates)	Frequency	7	7
	Percentage	39%	78%
	Confidence limits	17-64%	40-98%
CU3 (strong>=5 plates)	Frequency	4	6
	Percentage	22%	67%
	Confidence limits	6-48%	30-93%

CU3: City University test, 3rd ed.; HRR4: Hardy Rand & Rittler test, 4th ed.; MR: Mollon Reffin minimalist test. Confidence limits: binomial 95% limits for proportions

Appendix 1. Deuteranopes (see Appendix 3 for key to heading superscripts).

Patient ID	Age	Anom	CU3			HRR4					Ishihara			MR		
		YmatchR[1]	RG scr[2]	diag cat[3]	diag/6[4]	scrn/6[5]	p/9[6]	d/9[7]	diag cat[8]	Extent[9]	?/12[10]	mild/ strong[11]	p/d[12]	p[13]	d[14]	diag cat[15]
31	14	12	0	d	5	1	3	7	d	2	0	3	d			
55	23	11	0	d	5	0	2	8	d	3	0	3	d			
59	50	13	0	d	3	0	1	6	d	3	0	3	d			
109	47	12	0	d	6	1	1	8	d	3	1	3	d	3	7	d
129	11	10	2	d	3	1	1	9	d	3	1	3	d	2	6	d
131	38	11	2	d	5	0	3	8	d	2	1	3	d	3	7	d
151	14	9	1	d	4	0	2	8	d	2	2	3	d	2	3	d
154	18	10	0	d	6	0	1	7	d	3	0	3	d	3	4	d
155	9	6 *	0	d	5	0	1	6	d	3	0	3	d	3	4	d
Mean	28	11	0.6	-	4.7	0.33	1.7	7.4	2.6	-	0.6	3	-	2.7	5.2	-

*This observer used low monochromatic yellow luminances to match ALL red/green mixtures.
Anom = anomaloscope; CU3 = City University Test, 3rd ed.; d = deutan; diag cat = diagnosis category; G = green;
HRR4 = Hardy Rand & Rittler Test, 4th ed.; MR = Mollon Reffin Test = p = protan; R = red; scrn = screening; Y = yellow

Appendix 2. Protanopes (see Appendix 3 for key to heading superscripts).

Patient ID	Age	Anom	CU3			HRR4					Ishihara			MR		
		Ymatch R[1]	RG scrn[2]	diag cat[3]	diag/6[4]	scrn/6[5]	p/9[6]	d/9[7]	diag cat[8]	extent[9]	?/12[10]	mild/ strong[11]	diag cat[12]	p[13]	d[14]	diag cat[15]
39	15	3	3	p	3	0	6	3	p	2	0	3	d			
7	14	8	0	p	2	0	6	2	p	3	0	3	d			
35	11	5	2	p	5	0	6	4	p	2	0	3	d			
121	18	2	0	d	3	1	7	1	p	3	0	3	d	6	2	p
133	9	2	0	p	2	0	6	3	p	3	1	3	d	6	1	p
29	15	5	0	d	3	0	6	3	p	2	1	3	d			
30	18	5	0	p,d	2	0	5	1	p	3	0	3	d			
110	40	1	0	p	5	0	5	1	p	3	0	3	d	6	2	p
107	30	2	0	p	3	0	6	1	p	3	0	3	d	6	2	p
61	12	2	0	p	5	1	9	6	p	2	0	3	d			
45	11	3	1	p	5	1	7	3	p	2	0	3	d			
86	11	1	0	p	4	0	7	0	p	3	1	3	d	5	3	p
140	9	2	0	p,d	2,2	0	5	0	p	3	1	3	d	6	3	p
101	10	5	1	p	1	0	7	1	p	3	0	3	d	6	1	p
141	12	1	0	p	3	0	7	2	p	3	0	3	d	6	3	p
144	28	1	1	p	4	0	7	0	p	3	0	3	d	6	3	p
145	13	2	0	p	3	0	7	0	p	3	0	3	d	6	2	p
147	23	2	0	p	4	0	6	0	p	3	0	3	d	5	2	p
Mean	17.3	2.8	0.4		3.3	0.2	6.4	1.7		2.7	0.2	3.0		5.8	2.2	

Anom = anomaloscope; CU3 = City University Test, 3rd ed.; d = deutan; diag cat = diagnosis category; G = green;
HRR4 = Hardy Rand & Rittler Test, 4th ed.; MR = Mollon Reffin Test = p = protan; R = red; scrn = screening; Y = yellow

Appendix 3. Captions for Superscript Headings in Appendices 1 and 2.

1.	YmatchR[1] = Anomaloscope: luminance of yellow (Y) in lower field to match monochromatic red (R) in upper field (possible range = 0 to 40).
2.	RGscrn[2] = Number of red/green targets detected out of 6 on Screening plates.
3.	diag cat[3] = Diagnostic category based on largest number of targets detected on Detection/Selection plates. p=protan, d=deutan, p=d: equal responses.
4.	diag/6[4] = Number of targets correctly identified out of 6 on Detection/Selection plates corresponding to CVD category
5.	scrn/6[5] = Number of targets correctly identified out of 6 on Screening Series plates 7 to 10.
6.	p/9[6] = Number of protan targets out of 9 identified on Diagnostic plates 11 to 20.
7.	d/9[7] = Number of deutan targets out of 9 identified on Diagnostic plates 11 to 20.
8.	Diag Cat[8] = Diagnosis category: protan (p) if protan score > deutan score; deutan (d) if deutan score > protan score.
9.	Extent[9] = extent of colour vision deficiency (CVD) as mild, medium or strong based on missed or incorrectly identified targets (mild=1, medium=2, strong=3).
10.	Number correct[10] = Number of plates read correctly (plates 2 to 13).
11.	mild/str[11] = CVD strength based on responses to plates 16 and 17. Mild=1, strong=3.
12.	p/d[12] = CVD category based on responses to plates 16 and 17. p=protan, d=deutan.
13.	p[13] = Saturation discrimination threshold on protan axis (maximum = 5). Failure to detect most saturated target recorded as 6.
14.	d[14] = Saturation discrimination threshold on deutan axis (maximum = 6). Failure to detect most saturated target recorded as 7.
15.	diag cat[15] = Diagnostic category: protan (p) if protan threshold > deutan threshold; deutan (d) if deutan threshold > protan threshold.