MEDICAL RESEARCH LABORATORY

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REPORT ON TRIAL OF ROYAL CANADIAN NAVY COLOUR VISION LANTERN IN COMPARISON WITH OTHER TESTS OF COLOR VISION

by

C. W. Shilling, Cdr. (MC), USN

18 January 1943

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Reference may be made to this report as follows: Shilling, C.W., "Report on trial of Royal Canadian Navy Colour Vision Lantern in comparison with other tests of color vision", MRL Color Vision Report No. 2, 18 January 1943.

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MEDICAL RESEARCH DIVISION
U.S. SUBMARINE BASE
NEW LONDON, CONNECTICUT

January 18, 1943

From: Senior Officer, Medical Research Laboratory
To: Research Division, Bureau of Medicine and Surgery, Navy Department, Washington, D.C.

Subj: Report on Trial of Royal Canadian Navy Colour Vision Lantern, in comparison with other tests of color vision

Ref: (a) BuM & S Research Division, Memorandum dated 11 June 1942
(b) Preliminary Report on Color Vision Testing, 12 September 1942

Encl: (1) Subject report.

1. In accordance and compliance with reference (a), Project V5-2, a report is presented on the Trial of the Royal Canadian Navy Colour Vision Lantern, in comparison with other tests of color vision.

/s/ C. W. SHILLING

Copy to:
Capt. J.C. Adams (MC) USN, Room 1801, Bureau of Medicine and Surgery, Navy Department, Washington, D.C.

Mr. Dean Farnsworth, Psychology Department, New York University, New York.

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SUMMARY

1. The Royal Canadian Colour Vision Lantern was tested in accordance with Project Order V5-2.

2. This report deals with five hundred of the men who were tested on the Royal Canadian Lantern in addition to other color tests in use in this Laboratory.

3. Tables and graphs showing results of these tests are presented, together with a discussion of their relative merits.

4. Advantages of the Royal Canadian Lantern appear to be:

   (a) Simplicity of administration. Little training necessary. Results not influenced by individual operators whereas the Edridge-Green lantern requires considerable training and is difficult to administer.

   (b) Short test -- approximately $1\frac{1}{2}$ minutes per normal individual. (The American Optical Company (A-O) plates complete -- $1\frac{1}{2}$ + 3 minutes; Edridge-Green complete -- 3+ minutes).

   (c) Simple to interpret and to score. Coaching or previous training has minor influence on results of lantern but marked influence on results of A-O plates.

   (d) Permits positive interpretation.

   (e) No special lighting required, therefore can always be given under standard conditions. A-O plates are seldom given under standard conditions, with consequent wide variance in results.

   (f) Less exacting in selection than A-O plates given and scored in accordance with existing instructions.

5. Disadvantages of the Royal Canadian Lantern are:

   (a) Requires dark room.

   (b) Does not screen malingerers effectively.

   (c) Does not permit fine gradations in interpreting type and degree of color blindness. (However, this is not necessary for service requirements).

   (d) Allows some slightly anomalous individuals to pass as normal.

6. The administration of the test was modified as noted in the text. These changes have proven valid and simplify the operation of the test.

7. If this test is to be used in our Navy, the instructions should be modified as follows:

(a) Do not require dark adaptation.

(b) Inform as to only red, green and white colors (thus obviating the necessity for evaluating other interpretations of the colors).

(c) One operator only is required.

TRIAL OF ROYAL CANADIAN COLOUR VISION LANTERN IN COMPARISON WITH OTHER COLOR VISION TESTS

This investigation was carried out in accordance with the Memorandum of the Medical Research Section, Bureau of Medicine and Surgery, Project V5-2. (Reference (a))

The equipment, personnel, and the technical details are the same as reported in the preliminary report, Reference (b). All tests discussed in this paper were described in the preliminary paper.

Again the work was accomplished and the report prepared by REED, John David, PhM.2c, USNR, who came to the Medical Research Laboratory from the Graduate School of Brown University.

The Royal Canadian Lantern is a table instrument, showing two horizontally disposed lights at a time. These are spaced one inch apart and moveable diaphragm makes it possible to use lights which are either .2 inches or .02 inches in diameter. The larger are used for demonstration and the smaller for testing purposes. There are three colors of filters used: -- deep red (Corning #241), standard signal green, and white. All nine possible pairs are shown at least once in the course of any one test, and the individual being tested is required to name them correctly. The brightness of these colored lights is approximately equal with the exception of one less bright white of a pair of whites. The red presents greater difficulty to the color anomalous individual than standard signal red.

The source of light in the lantern is a pre-focussed 32 candle power automobile headlight bulb running from an 8-volt transformer, and its intensity is controlled by means of a rheostat. The proper illumination is determined by a built-in photoelectric cell. From the bulb the light passes through opal glass and the various colored filters and is directed toward the subject.

The filters are mounted in a disc which is rotated to present the nine different color combinations. The whole instrument is housed in a black-painted box with dim recessed floodlights on the back for the use of the examiner. The face of the box is approximately eleven inches wide and fourteen inches high, and the body is about fifteen inches long.

The instructions, issued by the makers, for administering the test require that the subject be dark adapted for at least ten minutes, following which he is led into a darkened room and seated twenty feet from the lantern exactly in line with the front apertures. He is instructed to name the colors he sees from left to right, and at the same time to raise the hand corresponding to the position of the colors named. Furthermore, an attendant or a helper in charge of the subject stands with one hand on each of the subject's shoulders to insure that there is no miscalling of the order. There are specific instructions for varying the order of the combinations presented, since the Canadians often had potential subjects in the room as well as the men being examined.

In experiments here it was found unnecessary to follow all these instructions exactly. The test was given by one individual without an assistant; and as the subjects were alone in the room with him, a fixed order of presentation of combinations could be maintained, thus leading to more constant results. It was also found unnecessary and even inadvisable to have the subjects raise their hands when they named the colors. If they did not read the colors from left to right on the first demonstration test with the large aperture they were reminded to do so, and this was found sufficient to insure proper performance. The instructions given to each subject were: "I will present pairs of

colored lights to you which you are to name, giving the left one first and then the right one. These are pure, simple colors and should be named as such. For example, don't say pink or crimson or anything like that; just say red. "Do you understand?" If the man said yes, he was shown a red-green combination with the large aperture and if he named the left one first and then the right one the examiner said, "I guess you understand", changed the aperture to the small size and started on the test series. If the subject said "red-blue" or "red-white" or made another such error on the red-green combination, he was not corrected by the examiner who went directly to the small aperture as before. The red was not miscalled on the large aperture by any of the men tested. If he gave the improper order, he was told again to give the left one first and then he would do so. If he said "left, red"; "right, green" or used some other means of indicating which was which, he was told merely to give the left one first without additionally calling it left. In no case was the subject told that the colors he named were correct or incorrect.

The order of the series as we presented it was: green-red, white-green, green-white, green-green, red-green, white-red, white-white, red-white, red-red, green-red, white-red. It will be seen that green-red, white-green, and red-white occurred twice. This order follows the instructions given with the lantern. It is probable that if we had used a different order, the responses given by color-normal individuals would have been slightly different. We gave two combinations of green and white before pairing the white with the red. The white, when presented with green, appears of a more yellowish cast than when presented with red. Since the first presentation of the white light was with green, the subjects had a tendency to call the white "yellow" or "orange", which they probably would not have had to the same degree if the first presentation of the white had been with red. We selected

this order for that very reason, so that the greatest variety of names for white would be given, and we could thus see what constituted an acceptable normal response for that color.

The white color in the lantern has a distinctly yellow cast, so much so that some individuals who are told that it is white insist that it is yellow and so call it. Other responses to it were orange, amber, red, and pink. The significance of these variations of response are analyzed: on the A.O. plates the men who made these divers responses were normal. We have further tested some of these men by means of the Farnsworth panel. The average performance of five men who consistently called the colors on the R.C.N. Lantern correctly (i.e., as they are labelled) is presented in Graph #1. This approximates the averages of those men who consistently called the blue "green" and the white "yellow", "orange", and "red" (Graphs #2 to #5) and demonstrates the insignificance of these responses, whereas the particular significance of the anomalous response of "green" to the white light, is presented in Graph #6. The calling of the white as "red" presents a more serious problem to the examiner. Occasionally a man will call "red" for white until he first sees it paired with the red color. Since the first combination of red and white occurs after two combinations of white and green, the subject has already committed himself and may continue to call the white "red", although the red is called correctly. If he does change, however, the examiner has merely to repeat the original combinations to determine if this response was due to terminology or to color deficiency. The response of "red" for white is the only ambiguous response and need actually give little trouble to the tester because it is usually accompanied by qualifying statements such as, "It is very light, but I guess it is red". This difficulty may be avoided by telling the men that there are red, green and white colors. In one case a color normal man

called the white "yellow" and, on being informed that there were only white, green, and red, changed his response of "yellow" to "red" - an acceptable response.

Instead of an analysis of which responses may be considered good, a more fruitful line of pursuit is in the analysis of what responses indicate color deficiency. The following responses should be considered errors:

For green, "white" or "red".

For red, "white" or "green".

For white, "green" or "blue".

If white is called "red" the response may be considered an error if the man has previously called the white correctly. A person who fails the test by miscalling white usually labels it "green" or "blue" as well as "red". In only one case out of 65 anomalous men was the white called "red" after being named correctly, without also being called "green" or "blue". The Canadians allowed "yellow" or "bluish-white" for white, but no other responses. We found that "bluish-white" did not occur, because of the instructions that "These are simple pure colors and should be named as such". Other responses were varied, however. Table I, discussed below, shows that other responses than those allowed by the Canadians should be considered correct.

The instructions with the lantern required a period of dark adaptation of at least 10 minutes before the test. There appears to be little reason for this. A 10-minute period is about one-third the length of time needed for complete dark adaptation, while it is about twice as long as is necessary to adapt the cones - the receptors for color vision. Again, due to the different rate at which people become adapted to darkness, it is impossible to predict the degree of dark adaptation after ten minutes. The man being tested is neither light adapted nor dark adapted, but somewhere in between. Finally, there is no apparent reason why an

individual should be dark adapted for such a test. Edridge-Green does not find it necessary in the use of his lamp, which is similar to the Royal Canadian Lantern in principle, although the former is more variable.

With these considerations in mind, we tested the efficacy of dark adaptation for the operation of the lantern. A number of individuals were dark adapted by means of night vision goggles which had opaque plastic material substituted for the ordinary red lenses. This was done to eliminate differential color adaptation. The subjects were seated in a lighted room, wearing the goggles, for 10 minutes, and were brought individually into the dark room by the examiner and then told to remove the glasses. We thus insured that they would be dark adapted without having them in the dark room previous to their test. After being tested on the Royal Canadian Lantern, these men were given the American Optical Company test.

Table I reports the responses of the 111 cases of dark-adapted individuals whom the AO test showed to be normal. In any routine test on the RC lantern, the total number of presentations of any one color is eight, although there may be rechecks later. Thus, white, red and green were presented 888 times each in testing 111 men, eight times to each man. The response may have been consistent to a given stimulus color, or may have varied. For example, white was called red consistently by 2 men (16 times) and altogether was called red 28 times.

Table II presents the responses of 219 men, shown by the AO plates to be color-normal, who were not dark-adapted. The only significant difference brought out by these tables is the fact that fewer men without dark adaptation tended to call the white light "yellow" than did those who had been adapted. Other than this, the period of dark adaptation does not seem to alter the responses of color-normal individuals.

As far as those with color defects are concerned, the lack of dark adaptation may alter the stringency of the test, though not to any great extent. The test still divides individuals into two groups to about the same degree of color deficiency. A man who failed the test while light adapted also failed it after being dark adapted. The reverse was true with one exception. We have tested an insufficient number of individuals to be certain of the dividing line between the effects of dark adaptation and of light adaptation on the Royal Canadian Lantern but since no one has as yet determined this point, either method is acceptable.

We may conclude then that the omission of the period of dark adaptation does not significantly alter the performance of normal or abnormal subjects nor reduce the efficacy of the test.

Any test used for large groups will be discussed outside the testing room, and potential examinees may obtain information about the nature of the test. If this test were to be rendered valueless by the subjects' knowing that only three lights - red, green and white, were presented, it would be useless as a means of testing color vision in a large organization such as the Navy. With this in view, we again modified the official instructions to the extent of telling certain subjects that there were only red, green and white lights. We tested 97 normal men after giving them this information and again found a variety of responses, but these variations were less than in the preceding tests. (Table III) Yellow was called several times, and one man insisted that the white was too reddish to be white, and so called it "red".

As regards anomalous men, we tested subjects first without informing them what the lights were and then told them that the lights were red, white and green. If they had failed the test previously, they did so again. We may conclude then that previous knowledge of the nature of the test does not impair its efficiency either for normal or abnormal individuals.

It is possible that men who are color blind may attempt to get practice with the test from civilian opticians. If training or coaching should enable such men to pass the lantern, it would not then be so desirable a test as if such experience had no effect. We actually coached individuals in this manner. "You called the red-green as 'red-white' (showing the red-green); this is red-white' now do you see the difference?" Extensive training at the time of the test and on the same instrument used for testing seemed to have little beneficial effect except, perhaps on a few borderline cases. Even though the number of errors decreases, the final goal of making no errors is not attained after training. Some borderline cases may be passed as a result of coaching, but this is not necessarily an argument against the lantern, since it is quite indefinite as to how a person's color vision should be to cause his rejection for service.

To summarize this section, we have modified the instructions given with the Royal Canadian Lantern in four ways, none of which decreases the efficacy of the test and all of which aid in simplifying and clarifying its operation.

1. The elimination of the assistant operator and the substitution of a careful and conscientious worker among the enlisted personnel for the doctor required by the Canadians makes the test much more available for constant and widespread use in the Navy.

2. The acceptance of other responses than the prescribed ones as "normal" must be insisted upon, since men accounted normal by the present Navy tests for color vision did not necessarily give the exact answers called for by the Canadian test.

3. The omission of the period of dark adaptation makes for a simpler testing situation, eliminates the need for dark adaptation equipment, and reduces the total time necessary for completion of the test.

4. The information as to what the colors in the lantern actually were was intended primarily as a test of the machine's value in a large organization. Since such information seems to make a negligible difference in the lantern's ability to divide a population accurately, it might be suggested that informing the subjects in advance as to the three correct responses would simplify both the testing and the grading procedure.

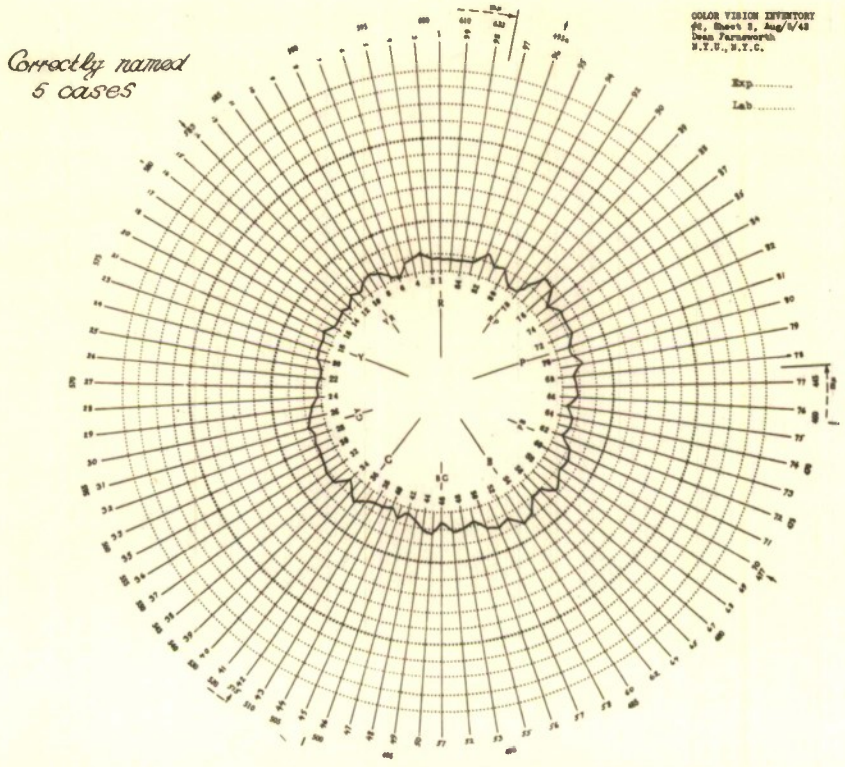
Approximately 2500 men were examined on the A.O. plates, and those who showed evidence of any deficiency at all on these plates were examined further. Such deficiency may be recognized by the tester in three ways: (1) total errors, (2) red-green responses to confusion plates, and (3) difficulty for the subjects in reading any of the plates. Mere tabulation of total errors does not give sufficient information and may even be misleading. Plates 19 and 20 are confusion plates as mentioned above; the normal individual reads 5 and 3, while the red-green color deficient sees 2 and 5. Plates 35 and 36 illustrate #3 above, as the man being tested is required actually to trace a wavy line in each plate. In Table IV is presented the average performance of 70 men whose AO performance showed some color deficiency judged by any of the three methods. It should be recognized that an average may gloss over important differences between types of color deficient individuals. Of these 70 men, 26 eventually passed the R.C. lantern although only nine of these 26 who passed made no errors on their first test. The other 17 correctly identified the colors on a retest. The remaining 44 men failed the lantern. From the AO as well as other tests it is apparent that passing the R.C. lantern does not necessarily mean that the man's color vision is normal, although the claims for the lantern deny this.

The present tests for color blindness in the Navy are a pseudo-isochromatic test (Stillings and latterly the American Optical Company's plates) supplemented by the Edridge-Green lantern. Although the instructions in the Manual are not clear as to the exact function of the Edridge-Green lantern, it is apparent that it is used in cases where individuals experience difficulty with the pseudo-isochromatic plates. The criticism concerning color naming which might be levelled against the R.C. lantern apply to the Edridge-Green lantern with even more emphasis because of the greater numbers of colors and combinations of colors. For example, the blue of the Edridge-Green lantern is decidedly a purple and the response of violet, lavender, or red must not be considered incorrect. This lamp requires an expert to administer it, and even in the hands of an expert it does not indicate individuals who might be dangerously color deficient, because of the large sized aperture used. Authorities agree that the Edridge-Green lantern does not reject certain individuals who can distinguish red and green near at hand but not at a distance.

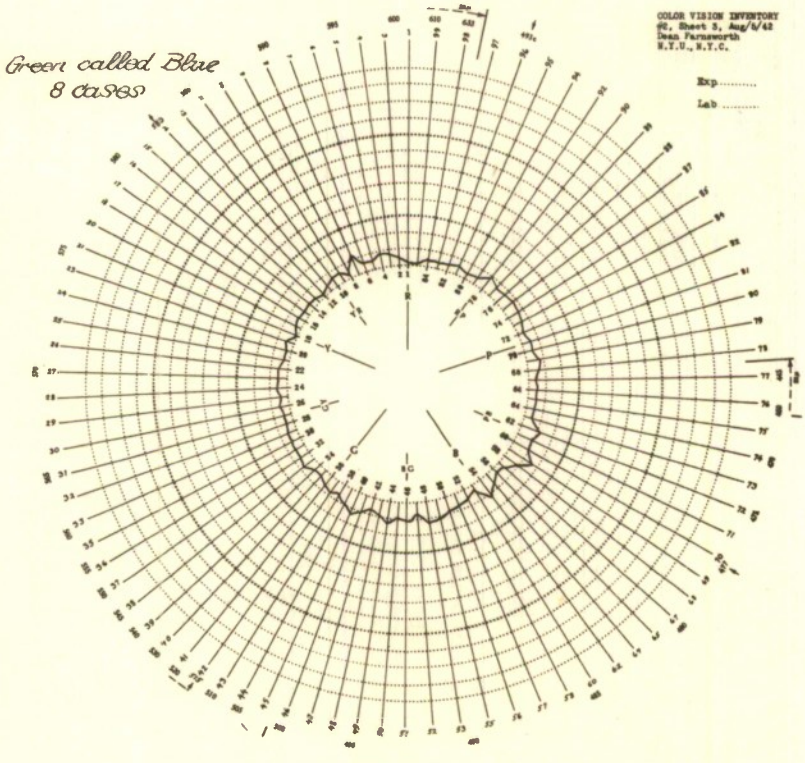
Since the R.C. lantern is also used to supplement pseudo-isochromatic tests it should be compared with the Edridge-Green lantern. There are three immediate advantages to the R.C. lantern. In the first place, it is a more difficult test than the Edridge-Green lantern. Secondly, it is simpler in operation and interpretation and, thirdly, it is less time consuming, about $1\frac{1}{2}$ minutes being required to administer the test completely.

Whether the Navy's test for color vision should be less stringent than the AO plates, properly administered, is problematical. Criteria for an applicant's color vision should be further investigated. The R.C. lantern approximates working conditions and should be considered in that light. It is an easier test than the pseudo-isochromatic type in that men with minor color

defects may fail the plates and yet pass the lantern. On the other hand it is a much more stringent test than the Edridge-Green lantern. A rigid investigation under actual field conditions is indicated prior to the establishment of new and definite standards for the minimum requirements for color vision. It is known that the requirements for color vision vary widely from job to job and it is probable that only a small percentage of the ratings in the Navy require excellent color perception.

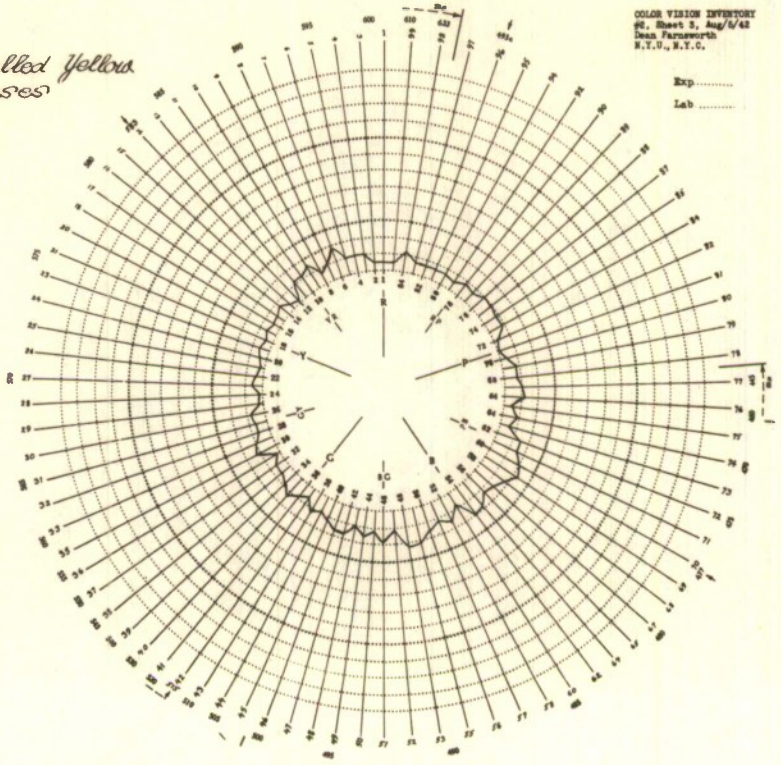


Graph I



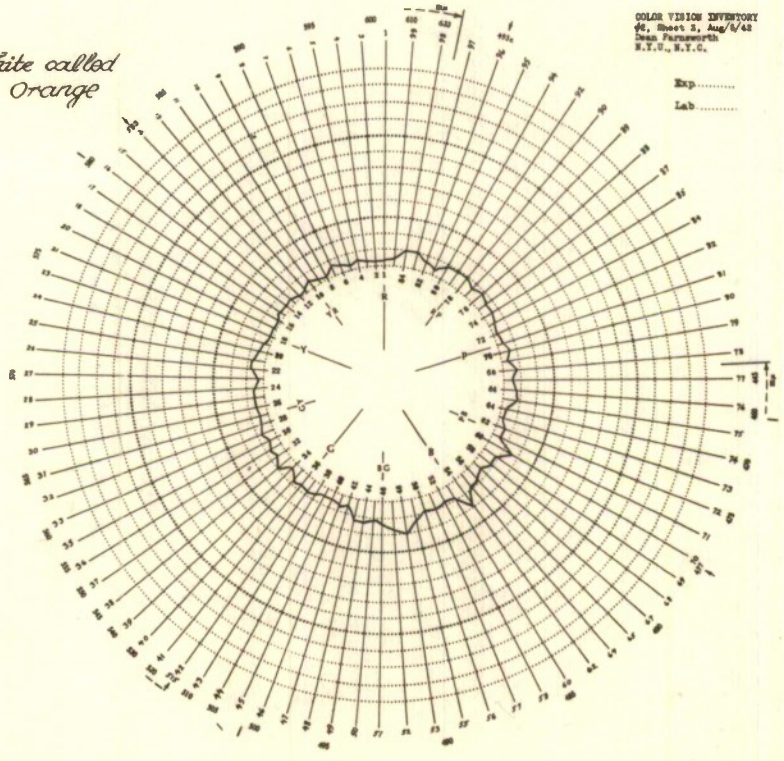
Graph II

White called Yellow
7 cases

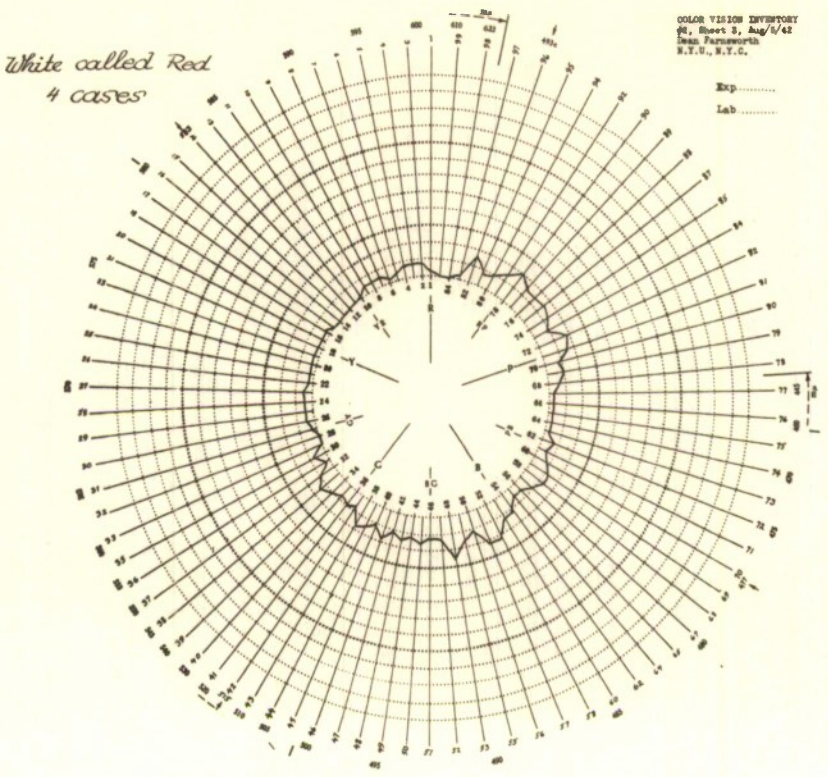


Graph III

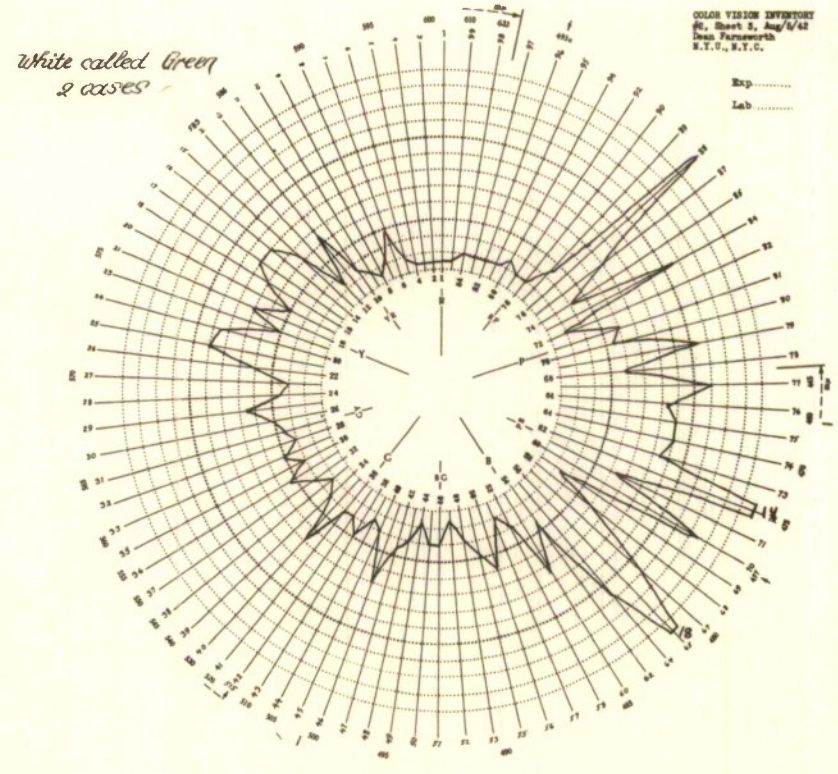
White called
Orange



Graph IV



Graph V



Graph VI

ROYAL CANADIAN COLOUR VISION LANTERN

111 dark-adapted subjects, who have normal color perception

TABLE I-a

White Stimulus Responses			Green Stimulus Responses			Red Stimulus Responses		
Color	Number	%	Color	Number	%	Color	Number	%
White	308	34.7	Green	831	93.6	Red	887	99.9
Yellow	473	53.3	Blue	56	6.3	Yellow	1	0.1
Orange	71	8.0	Red	1	0.1			
Red	28	3.1						
Amber	5	0.6						
Pink	2	0.2						
Green	1	0.1						
Total	888	100.0		888	100.0		888	100.0

TABLE I-b

White stimulus Consistent responses			Green Stimulus Consistent responses			Red Stimulus Consistent responses		
Color	Individuals	%	Color	Individuals	%	Color	Individuals	%
White	29	26.1	Green	101	91.0	Red	110	99.1
Yellow	49	44.2	Blue	6	5.4			
Orange	7	6.3						
Red	2	1.8						
Total-	87	78.4		107	96.4		110	99.1
Incon-sistent	24	21.6		4	3.6		1	0.9
TOTAL	111	100.0		111	100.0		111	100.0

ROYAL CANADIAN COLOUR VISION LANTERN

219 light-adapted subjects, who have normal color perception

TABLE II-a

White Stimulus			Green Stimulus			Red Stimulus		
Responses			Responses			Responses		
Color	Number	%	Color	Number	%	Color	Number	%
White	1101	62.8	Green	1481	84.5	Red	1745	99.6
Yellow	554	31.6	Blue	269	15.4	Black	4	.2
Orange	25	01.4	White	1	0.1	Green	3	.2
Red	44	12.5	Red	1	0.1			
Amber	7	0.4						
Pink	2	0.1						
Brown	1	0.1						
Black	9	0.5						
Green	9	0.5						
Total	1752	100.0		1752	100.0		1752	100.0

TABLE II-b

White Stimulus			Green Stimulus			Red Stimulus		
Consistent Responses			Consistent Responses			Consistent Responses		
Color	Individuals	%	Color	Individuals	%	Color	Individuals	%
White	106	48.4	Green	174	79.5	Red	215	98.2
Yellow	47	21.5	Blue	25	11.4			
Red	1	0.5						
Black	1	0.5						
Total	155	70.9		199	90.9		215	98.2
Incon-sistent	64	29.1		20	9.1		4	1.8
TOTAL	219	100.0		219	100.0		219	100.0

ROYAL CANADIAN COLOUR VISION LANTERN

97 light-adapted informed subjects, who have normal color perception

TABLE III-a

White Stimulus Responses			Green Stimulus Responses			Red Stimulus Responses		
Color	Number	%	Color	Number	%	Color	Number	%
White	725	93.4	Green	773	99.6	Red	776	100
Red	22	02.8	White	3	0.4			
Yellow	27	03.5						
Green	2	0.3						
Total	776	100.0		776	100.0		776	100

TABLE III-b

White Stimulus Consistent Responses			Green Stimulus Consistent Responses			Red Stimulus Consistent Responses		
Color	Individuals	%	Color	Individuals	%	Color	Individuals	%
White	82	84.5	Green	94	96.9	Red	97	100
Red	1	1.0						
Yellow	3	3.1						
Total	86	88.6		94	96.9		97	100
Incon-sistent	11	11.4		3	3.1		0	0
TOTAL	97	100.0		97	100.0		97	100

PASSED					FAILED			
Average of Errors on AO					Average of Errors on AO			
Number of cases	Total	#19,20	#35,36	Errors on R.C. Lantern	Number of cases	Total	#19,20	#35,36
9	24.1	1.8	1.0	0	-	---	---	---
8	26.5	1.9	1.3	1	2	25.5	1.5	1.5
6	28.5	1.8	1.3	2	1	34.0	2.0	2.0
3	18.0	1.0	0.3	3	9	28.8	1.8	1.0
				4	8	25.9	1.8	1.5
				5	6	24.5	1.7	1.0
				6	7	31.1	1.9	1.6
				7	10	31.6	1.8	1.8
				8	1	29.0	2.0	2.0
26	23.6	1.7	1.0	TOTAL	44	28.4	1.8	1.4

TABLE IV.