Pacific University
CommonKnowledge

College of Optometry | Theses, Dissertations and Capstone Projects

1978

A comparative evaluation of anomaloscopes: Pickford-Nicholson & Nagel

Marlene J. Susumi
Pacific University

Diane R. Rosenstein
Pacific University

Recommended Citation
Susumi, Marlene J. and Rosenstein, Diane R., "A comparative evaluation of anomaloscopes: Pickford-Nicholson & Nagel" (1978). *College of Optometry*. 502.
https://commons.pacificu.edu/opt/502

This Thesis is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in College of Optometry by an authorized administrator of CommonKnowledge. For more information, please contact CommonKnowledge@pacificu.edu.

A comparative evaluation of anomaloscopes: Pickford-Nicholson & Nagel

Abstract

Included among color vision testing instruments are the Nagel anomaloscope and the Pickford-Nicholson anomaloscope. The Nagel is a spectral instrument whereas the Pickford-Nicholson uses filters. This paper examines how closely the two instruments actually correspond. It is concluded that both instruments do quantitatively yield similar results on both normals and color deficients. The standard deviations of both the means and ranges on the two instruments are equal, at the .02 level of significance .

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Oscar W. Richards

Subject Categories

Optometry

This thesis is available at CommonKnowledge: https://commons.pacificu.edu/opt/502

Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the “Rights” section on the previous page for the terms of use.

If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see “Rights” on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to:.copyright@pacificu.edu

A COMPARATIVE EVALUATION OF ANOMALOSCOPES: PICKFORD-NICHOLSON & NAGEL

IN PARTIAL FULFILLMENT
FOR THE DEGREE OF
DOCTOR OF OPTOMETRY
BY

MARLENE J. SUSUMI
AND
DIANE R. ROSENSTEIN

Doctoral Thesis for partial
fulfillment of the requirement for
the degree of Doctor of Optometry from
Pacific University College of Optometry

Advisor Approval

Oscar W. Richards, Ph. D.

Many thanks to Doctor Oscar Richards for
his help and advice on and in the completion of our
study on color deficiencies using the Nagel
and the Pickford-Nicholson.

A COMPARATIVE EVALUATION OF ANOMALOSCOPES: PICKFORD-NICHOLSON & NAGEL

ABSTRACT

Included among color vision testing instruments are the Nagel anomaloscope and the Pickford-Nicholson anomaloscope. The Nagel is a spectral instrument whereas the Pickford-Nicholson uses filters. This paper examines how closely the two instruments actually correspond. It is concluded that both instruments do quantitatively yield similar results on both normals and color deficients. The standard deviations of both the means and ranges on the two instruments are equal, at the .02 level of significance.

INTRODUCTION

Eight percent of the male population and 0.5 percent of the female population have some type of color vision defect. There are various types of color vision defects and many types of instruments to detect and measure them. The Nagel anomaloscope is a spectral matching instrument. A bisected circle of light is shown to the subject, the top of which is a variable mixture of red and green while the bottom is a spectral yellow varying in luminance. Two knobs, one controlling each half, permit matching of the two hemispheres in terms of hue and luminance. The two knobs are calibrated and scaled such that they furnish the coefficients a, b, and c of the following Raleigh equation:

$$(a)\ (\text{red}) \ \& \ (73\text{-}a)\ (\text{green}) \sim (c)\ (\text{yellow}).$$

The normal trichromat will solve the above equation with $42(\text{red}) \ \& \ (73 - 42)\text{green} \sim 15\ (\text{yellow})$. The zero value on the red-green knob indicates that no red and all green light is perceived by the subject. At 73 scale units the

reverse is true, no green and all red is seen by the subject.

The dichromat will match the whole range of these instruments, therefore only anomalous trichromats were considered in the study. The protans need more red in their match, thus need a higher "a" value. The deutans will need more green in their match, leading to a lower "a" value.

The Pickford-Nicholson anomaloscope is a simple colorimeter, using lamps and color filters. The color filters chosen correspond well with the spectral lights of the Nagel.

Subjects were tested on both instruments, comparing color defect classifications and ranges. Normals were used as the control. The criteria for normals was three standard deviations on the Nagel anomaloscope.

METHOD

Subjects were tested using the Nagel, Pickford-Nicholson and the Farnsworth D-15 color vision test.

The Farnsworth D-15 color caps were arranged in random order as follows as derived from a random table: 10, 1, 7, 2, 8, 11, 9, 5, 3, 15, 12, 6, 13, 4, 14. The test was given under the Criticolor lamp.

Testing with the Nagel anomaloscope was first done by setting the instrument on the normal setting:

42 red/green and 15 yellow.

Subjects were then asked if the top half of the circle looked the same color as the bottom half. A positive response indicated that the subject was either normal or a dichromat. The red/green knob was then moved to 73 and then down to 0, to differentiate between a normal and a dichromat. Normals do not match at either end of the scale whereas dichromats do.

If the initial response was negative, this indicated that the subject was an anomalous trichromat. By bracketing the red/green knob, matching ranges were found for the anomalous trichromat.

With the Pickford-Nicholson anomaloscope, the subjects were first asked if the halves of the circle were the same color, when the left and right slides corresponded to a "normal" setting. This was about 30 for the left shutter and 35 for the right shutter. The "normal" setting was determined by the readings obtained from "normals" as classified by the Nagel. The left shutter was set on 20 scale units and the right on 80. The same procedure of bracketing, as was used with the Nagel was followed. Ranges were found in which the subject matched the red/green setting by turning the yellow knob.

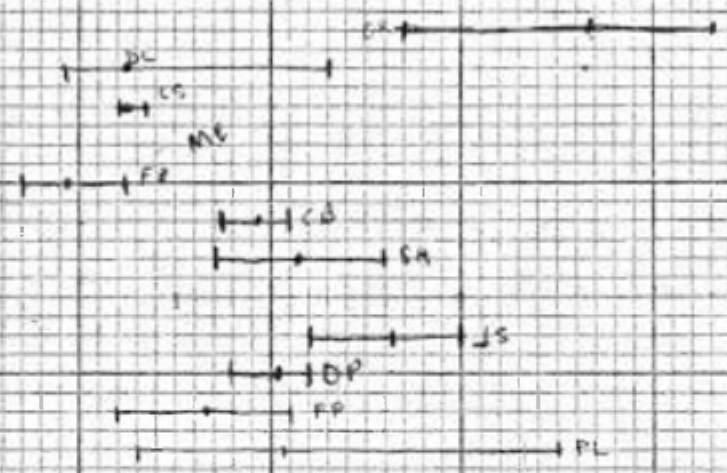
With both anomaloscopes the subjects controlled only the yellow luminosity knob, while the experimenter controlled the red/green knob.

Graph II P-N T skulls at 60
1 " at 20

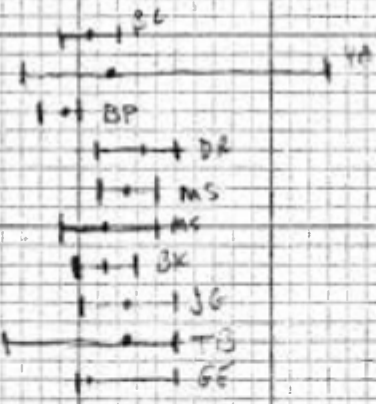
"THE CHAMPION LINE" NO. 810
SECTION 10 SQUARES TO INCH

30 40 50 60 70 80

DEFICIENTS



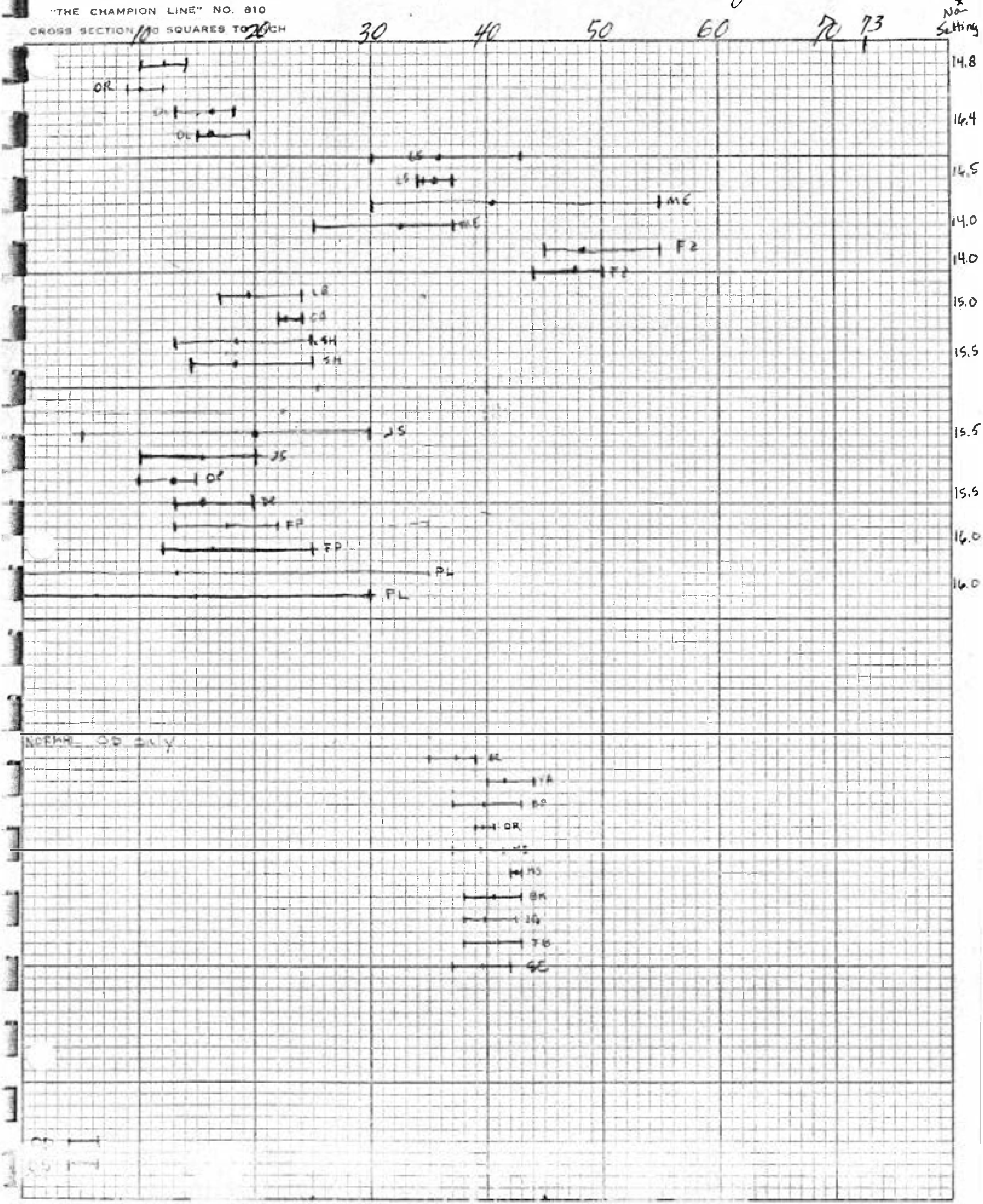
NORMALS CO STEV



OC
CG

Graph I

Nagel



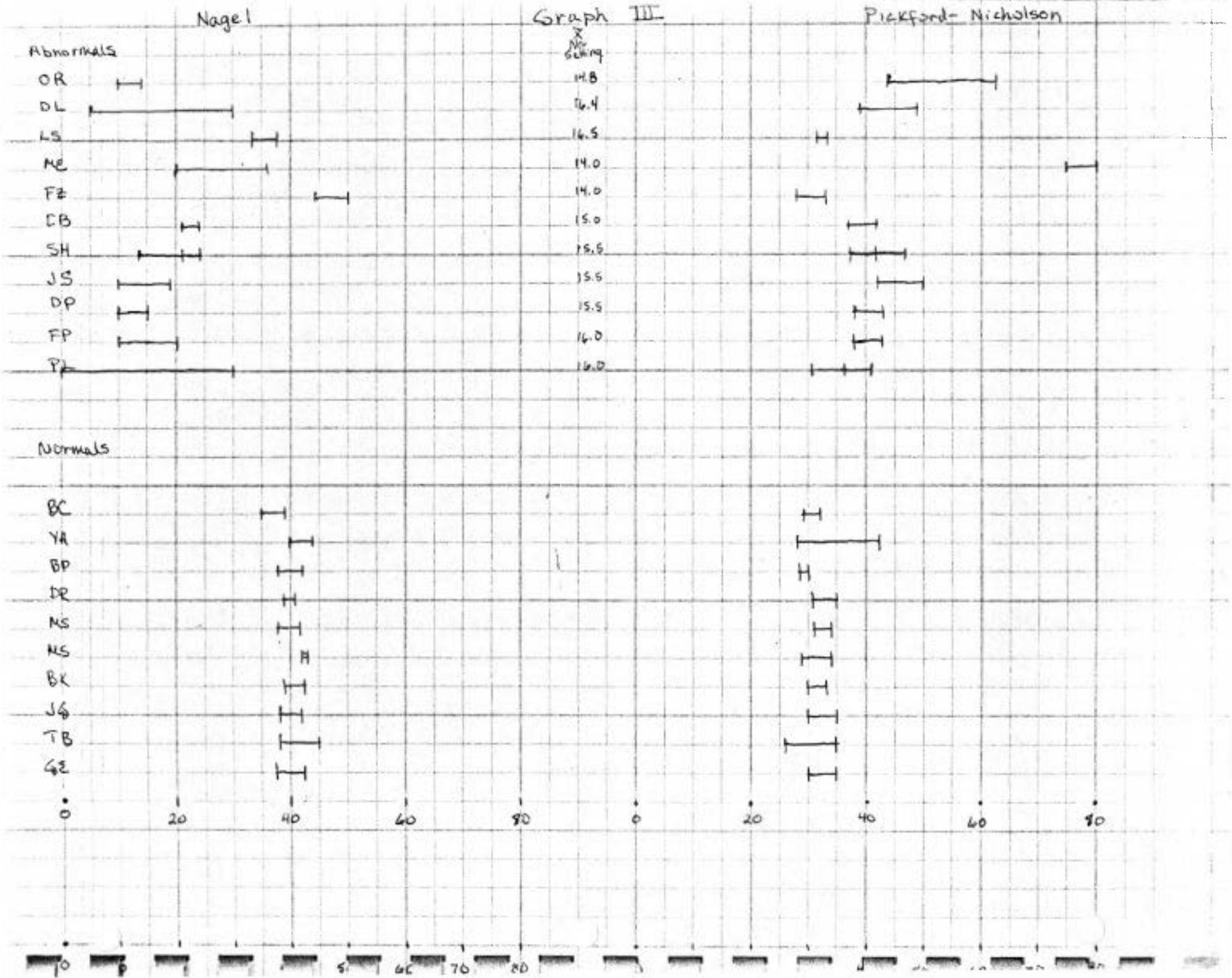

Nagel
Graph III
Pickford- Nicholson
Abnormals
OR
DL
LS
ME
FE
CB
SH
JS
DP
FP
PE
Normals
BC
YR
BP
DR
MS
NS
BK
JG
TB
GE
X No Scoring
14.8
16.4
16.5
14.0
14.0
15.0
15.5
15.5
15.5
16.0
16.0
0
20
40
60
80
0
20
40
60
80
10
70
80

Table I
NORMALS

NAME	RANGE OD	OD X	RANGE OS	OS X	OD OS 2	RANGE	X	RANGES
1.B.C.	35-39=4	37.4	37-40.5	38.8	38.1	29-32	30.1	1
2.Y.A.	40-44=4	41.6	40-43	41.4	41.5	27-43	31.7	12
3.B.P.	37-43=6	39.8	39-43	39.3	39.5	28-30	29.2	4
4.D.R.	39-40.5	39.8	38-42	39.4	39.6	31-35	33.2	2.5
5.M.S.	37-41.5=4.5	39.7	38-41	39.6	39.6	31-34	32.5	1.5
6.M.S.	42-43=1	42.8	42-43	42.9	42.8	29-34	31.8	4
7.B.K.	39-42=3	40.8	38-42	40.2	40.5	30-33	31.1	0
8.J.G.	38-42.5=4.5	39.9	38-42	39.2	39.6	30-35	32.8	1.5
9.T.B.	38-45=7	41.0	35-45	40.5	40.7	26-35	32.8	.2
10.G.E.	37-42=5	39.6	37-40	37.9	39.7	30-35	30.6	0
		4024		3499			315.8	

$\Sigma X = 40.5$

$\bar{X} = 4.05$

$\Sigma X = 28.5$

$\bar{X} = 2.85$

Table II

Nagel $\bar{X}=401.6$ $\tilde{X}=40.2$		PN $\bar{X}=315.8$ $\tilde{X}=31.6$	
$(x-\tilde{X})$	$(x-\tilde{X})^2$	$(x-\tilde{X})$	$(x-\bar{X})^2$
1. 2.1	4.41	1.5	2.25
2. 1.3	1.69	.1	.01
3. .7	.49	2.4	5.76
4. .6	.36	1.6	2.56
5. .6	.36	.9	.81
6. 2.6	6.76	.2	.04
7. .3	.09	.5	.25
8. .6	.36	1.2	1.44
9. .5	.25	1.2	1.44
10. .5	.25	1	1
	$\lesssim S^2 = 15.02$		$\lesssim S_2^2 = 15.56$
	$\bar{S}^s = 1.502$		$\bar{S}^2 = 1.556$
	$S = 1.225$		$S = 1.24$

$$F \quad \frac{S_2^2}{S_1^2} \quad \frac{1.556}{1.502} = 1.04$$

Nine degrees freedom .02 level

5.35 $F_{.02}$

Accept null hypothesis

RANGES Table III

	NAGEL $(x-\bar{X})$ $\bar{X}=4.1$	$(x-\bar{X})^2$	PN $(x-\bar{X})$ $\bar{X}=2.9$	$(x-\bar{X})^2$
1.	.1	.01	.1	.01
2.	.1	.01	13.1	171.6
3.	1.9	3.61	.9	.81
4.	2.6	6.76	.1	.01
5.	.4	.16	.1	.01
6.	3.1	9.61	2.1	4.41
7.	1.1	1.21	.1	.01
8.	.4	.16	2.1	4.41
9.	2.9	8.41	6.1	37.21
10.	.9	.81	2.1	4.41

$\leq S^2 = 30.75$

$S^2 = 3.075$

$S = 1.75$

$\leq S_2^2 = 224.09$

$S^2 = 22.41$

$S = 4.73$

$$\frac{S_1^2}{S_2^2} = \frac{224.09}{30.75} = 7.28$$

$F_{.02} = 5.35$

Reject null hypothesis

Table IV

Anomalous Individual Findings on the Nagel and the Pickford-Nicholson

	NAME	NAGEL OD: RANGE	X	OS: RANGE	X	YELLOW	ΔRANGE	PICKFORD-NICHOLSON RANGE	X	Δ RANGE
1.	O. R.	9-12	10	10-14	12.2	14.8	3	48-63	56.7	15
2.	D. L.	0-20	16.4	5-30	16.5	16.4	20	29-43	32.5	14
3.	L. S.	30-40	36	34-37	35.5	16.5	10	32-33.5	32.6	1.5
4.	M. E.	36-45	40.5	20-36	32.4	14	9	75-80	77.5	5
5.	F. Z.	45-55	48.8	44.5-50	47.9	14	10	27-32.5	29.1	5.5
6.	C. B.	17-24	19.8	22-24	22.8	15	7	37.5-41	39.2	3.5
7.	M. V.	DEUTERANOPE - MATCHED OVER ENTIRE RANGE								
8.	S. H.	14.5-25	18.5	13-25	18.2	15.5	10.5	37-46	41.8	9
9.	B. G.	PROTANOPE - MATCHED OVER ENTIRE RANGE								
10.	R. L.	DEUTERANOPE - MATCHED OVER ENTIRE RANGE								
11.	J. S.	5-30	20	10-19	15.4	15.5	25	42-50	46.6	8
12.	D. P.	10-15	13	10-15	15.5	15.5	5	38-42	40.3	4
13.	F. P.	13-20	17.8	10-20	16.4	16	7	32-41	36/6	9
14.	P. L.	5-25	13.2	0-30	15	16	20	33-55	40.7	22
							$\bar{X}$=11.5			$\bar{X}$ = 8.8

Table V

Standard Deviation of the Mean on Abnormals

		NAGEL			PICKFORD-NICHOLSON		
	Name	$X\left(\frac{OD\ OS}{2}\right)$	$(X-\bar{X})$	$(X-\bar{X})^2$	X	$(X-\bar{X})$	$(X-\bar{X})^2$
1.	O. R.	11.1	-11.6	134.6	56.7	13.7	187.7
2.	D. L.	16.4	-6.3	39.7	32.5	-10.5	110.3
3.	L. S.	35.7	13	169	32.6	-10.4	108.2
4.	M. E.	36	13.3	176.9	77.5	34.5	1190.3
5.	F. Z.	48.3	25.6	655.4	29.1	-13.9	193.2
6.	C. B.	21.3	-1.4	1.96	39.2	-3.8	14.4
7.	S. H.	18.3	-4.4	19.4	41.8	-2.0	4.0
8.	J. S.	17.7	-5	25	46.4	3.4	11.6
9.	D. P.	14.5	-8.2	67.2	40.3	-2.7	7.3
10.	F. P.	17.2	-5.6	31.4	36.6	-6.4	41.0
11.	P. L.	14.1	-8.6	74.0	40.7	-2.3	5.3
		$\Sigma\bar{X}=250.5$		$\Sigma S^2=1394.6$	$\Sigma X=432.7$		$\Sigma s^2=1873.3$
		$\frac{\Sigma X}{11}=22.8$		$\frac{\Sigma s^2}{11}=126.8$	$\frac{\Sigma X}{11}=39.3$		$\frac{\Sigma s^2}{11}=170.3$
				$s=11.3$			$s=13.04$

F DISTRIBUTION: $\frac{s_2^2}{s_1^2}$ $\frac{1873.3}{1394.6}$ 1.34 and $F_{.01}$ 4.85.

Table VI

Standard Deviation of the Means for the Ranges for the Abnormals

	Name	NAGEL X	$(X-\bar{X})$	$(X-\bar{X})^2$	PICKFORD-NICHOLSON X	$(X-\bar{X})$	$(X-\bar{X})^2$
1.	O. R.	3	-8.5	72.3	15	6.2	38.4
2.	D. L.	20	8.5	72.3	14	5.2	27
3.	L. S.	10.	-1.5	2.3	1.5	-7.3	53.3
4.	M. E.	9	-2.5	6.3	5	-3.8	14.5
5.	F. Z.	7	-4.5	20.3	3.5	-5.3	28.1
6.	C. B.	10.5	-1	1	9	0.2	0.04
7.	S. H.	25	13.5	182.3	8	-0.8	0.64
8.	J. S.	5	-6.5	42.3	4	-4.8	23.1
9.	D. P.	7	-4.5	20.3	9	0.2	0.04
10.	F. P.	10	-1.5	2.3	22	13.2	174.2
11.	P. L.	20	8.5	72.3	5.5	-3.3	10.9
		$\Sigma X = 126.5$		$\Sigma s^2 = 496.7$	$\Sigma X = 96.5$		$\Sigma s^2 = 370.2$
		$\Sigma X/11 = 11.5$		$\Sigma s^2/11 = 45.2$	$\Sigma X/11 = 8.8$		$\Sigma s^2/11 = 33.7$
				$s = 6.7$			$s = 5.8$

The F distribution : $F_{.01} = \frac{496.7}{370.2} = 1.34$ where $F = 4.85$.

RESULTS

The F distribution test was used to determine whether both instruments do quantitatively yield equivalent results with both normals and color deficients. The standard deviation of the means was 1.22 and 1.24 for the Nagel and the Pickford-Nicholson respectively. The ranges were also compared at the 0.02 level of significance and this test revealed each range to not be equal.

The standard deviation of the means for abnormals on the Nagel and the Pickford-Nicholson were 11.3 and 13.04 respectively. With the F distribution, the null hypothesis was accepted. Since the value obtained for F was close to one, there was little risk in making the assumption that the two population standard deviations were equal. The standard deviation of the range on the Nagel was 6.7 and it was 5.8 for the Pickford. The null hypothesis was once again accepted.

The score of an anomalomous individual could not be estimated on one instrument if the score on the other instrument was known. Classifications, however, were the same from one instrument to the other so that a deutan on the Nagel was also detected as a deutan on the P-N.

DISCUSSION

The experimenters found that more subjects had difficulty matching colors with the Pickford-Nicholson anomaloscope than with the Nagel. This could be why the ranges between the instruments differed significantly for the normals. Matching with the filters of the P-N must not be as sensitive as matching with the Nagel and therefore the ranges were extended. However, there was a wider variance of ranges on the Nagel than on the Pickford with the deficients. Eight out of eleven deficients had about the same ranges on both instruments. The average range on the Nagel was 11.5 units and on the Pickford-Nicholson it was 8.8 units.

If a subject had X="B" on the Nagel, the X on the Pickford could not be predicted. No set pattern was detected. Six out of eleven anomals had a P-N finding two times the finding on the Nagel. Subjects #6 & 8 had about the same results on both instruments as did subjects #12 and #14. However subjects #6 & 11 both had about 20 on the Nagel but #6 had 39.2 on the P-N whereas #11 had 46.4.

Because of the variations between individuals, and the different degrees of color defects, an estimate could not be made on one instrument if results on the other was known.

For each individual, though, the result on the Nagel yielded the identical color defect on the Pickford-Nicholson. It could be concluded that the filters in the Pickford-Nicholson do work similarly to the spectral Nagel anomalscope.

BIBLIOGRAPHY

Lakowski, R, "Calibration, Validation and Population Norms for the Pickford-Nicholson Anomaloscope.","The British Journal Of Physiological Optics," Vol. 26, No. 3, 1971, pages 166 - 182.

Linksz, Arthur, "Examination of Color Vision with the Anomaloscope, Nagel type," Compiled by Arthur Linksz, M. D., New York, N. Y.

Willis, Marion, and Farnsworth, Dean, "Comparative Evaluation of Anomaloscopes." Vol. XI, No. 7, 1952.