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Binocular refraction- a comparative technique

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Abstract

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Binocular Refraction - A Comparative Technique

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by

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APPROVED

FOURTH YEAR OPTOMETRY PROJECT

Chairman

Advisor

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D.B.
T.C.
G.D.

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Introduction

Examination of the literature on distance refractive techniques over the past thirty years shows recurrent interest in binocular refractive techniques as compared to conventional monocular refractive procedures. No single binocular refractive technique has developed world wide acceptance or been shown to be superior to conventional procedures. Quantitative comparative studies are much less common than are the published descriptions of techniques. Binocular refractive techniques have been described by Sugar,[1] Turville,[2] Humphriss,[3] Van Wien,[4] Frantz,[5] Baldwin,[6] and many others.

Quantitative comparisons between conventional and binocular refractive procedures have been reported by Miles,[7] Morgan,[8] and Rosenberg and Shermen.[9] Miles found an average cylinder axis change of 8 degrees under binocular conditions. Morgan found a change in axis of 10 degrees or more in 2% of the subjects of his study. He found no significant change in cylinder power. Rosenberg and Sherman using the American Optical Vectographic slide studied 47 patients under identical conditions. They found no change in cylinder power but found an axis change greater than 3 degrees in 10% of their subjects under binocular conditions. Their study included measurements of visual acuity, binocular instability, fixation disparity, and stereopsis. Difference in visual acuity between the standard and Vectographic slide of less than one line in 32 subjects and a difference of one line in 9 subjects was reported. They maintained that the difference was not due to the test slide because the visual acuity difference was in only one eye. Their explanation of the difference in visual acuity doesn't seem reasonable for several reasons. Our preliminary clinical observations indicated that if there was a difference it was frequently observed in both eyes. We found no report in the published literature that indicates a significant difference in monocular acuities under binocular viewing conditions.

Problem

Our study was conducted for several reasons. First, we wanted direct clinical experience with a recognized binocular refraction method. Secondly, we wanted to compare binocular refractive procedures at distance with the conventional distance refractive procedures as taught at Pacific University College of Optometry Clinic. Thirdly, we wished to compare our results with the published literature. This study was designed to investigate quantitative and qualitative differences between these two refractive procedures as contrasted with examiner preferences or opinions. The AO Vectographic slide was selected for a comparative study because of its availability and because of the study published by Rosenberg and Sherman.

Quantitatively we investigated the difference in measurements of anisometropias, astigmatic axis and power, and the distal endpoint of accommodation (punctum remotum). We also wanted to evaluate the use of the AO Vectograhic slide in detecting binocular instabilities and suppressions, measuring stereopsis and neutralizing fixation disparities.

Procedure

In order to investigate the problem as previously stated, sixty-three subjects were chosen. Their ages ranged from six to forty years, and the age distribution varied as shown in Table I:

Table I: . . . . . .

Age Range	Number of Subjects
6 - 11	4
12 - 17	3
18 - 23	32
24 - 29	18
30 - 35	3
36 - 40	3

Fifty of the sixty-three subjects were Optometry students and were thereby classified as experienced observers. The other thirteen subjects were a convenient sample of clinical patients. Only patients without strabismus, and with no apparent pathology were accepted for comparative purposes.

Standardization of instructions and the discrimination requirements received special attention so that during the tests that were common to both methods of refraction, the examiner could give the same instructions to each subject. The three clinical rooms used during the investigation were carefully chosen and matched with regard to general room illumination, distance, background contrast, and detail and surround luminance from the screen onto which the letters were projected. The A.O. project-o-chart slide used for the conventional refraction was the model 11103, and the slide used for the binocular refraction was the model 11243. Table II contains a description of the room and screen conditions.

Table II: . .

Room Illumination	Slide Used	Detail Luminance	Surround Luminance	Luminous Contrast
0 fc	Conv.	1.7 fL	72.0 fL	0.98
0 fc	Binoc.	4.9 fL	15.4 fL	0.68
2.5 fc	Conv.	5.4 fL	75.2 fL	0.93
2.5 fc	Binoc.	5.1 fL	16.0 fL	0.68
14.4 fc	Conv.	8.5 fL	83.2 fL	0.90
14.4 fc	Binoc.	8.9 fL	20.0 fL	0.55

The zero footcandle condition occurred under total room darkness, the 2.5 level was the room illumination with the light nearest the screen turned off, and the 14.4 level occurred under full room illumination. The luminance contrast was calculated from the formula $C_L = 1-L_1/L_2$, where L_1= the detail luminance and L_2= the surround luminance. The chair in each of the rooms was moved so that the subject sat at the angle of reflection of the projected light. The 2.5 fc level of illumination was maintained throughout each examination, except during the Bichrome test.

The testing procedures followed the standard Pacific University clinical methods. The same tests were performed under conventional and binocular testing conditions. A polaroid analyzer was used with the binocular condition to effectively allow input to one eye while the other observed an empty lighted field corresponding to the area of letters in the eye being tested. The peripheral visual field was common to both eyes.

A static retinoscopy with fixation at eighteen feet provided the basis on which the successive subjective refractive procedures were performed. The Red-Green Bichrome test provided the lens control for a cylinder power and axis modification. This modification was accomplished with the Jackson Cross Cylinder, and this result was further modified with a cylinder power and axis rock on the 20/40 line of letters. The "just noticeable difference" for axis range was recorded. An anisometropia evaluation was accomplished with the Bichrome test and also with a 20/30 Equalization. The latter employed Risley prisms during the conventional exam, and the split chart during the binocular exam. A far subjective finding, the maximum plus that gave 2/3 of the 20/20 line, was found and followed by the determination of the lens that gave the subjective best visual acuity. The acuities were noted after both the conventional and the binocular subjective refractions. Acuities were again taken with the binocular subjective to best visual acuity in place and using the conventional slide. Any differences were noted. The sequence of performing the conventional before the binocular exam was altered to the binocular before the conventional for every other subject.

Supplemental to the static retinoscopy and the subjective findings, an evaluation of suppression response, fixation disparity, and stereopsis was obtained with the binocular slide. Suppressions and a measure of binocular instability were noted from lines of "mixed letters", some common to only each eye. Fixation disparity, both lateral and vertical was neutralized using the target with the central binocular lock. The degree of stereopsis was noted from the four line target. Finally if any fixation disparity existed, this was corrected for with one Risley prism before the left eye, and the quality of the stereo response was re-evaluated for any subjective changes. Table III summarizes the testing sequence:

Table III: . . .

Conventional Refraction	Binocular Refraction
1. Distance static retinoscopy	1. Distant static retinoscopy
2. Red-Green Bichrome Test - 20/50 line	2. Red-Green Bichrome Test - 20/50 line
3. Jackson Cross Cylinder Test - 20/40	3. Jackson Cross Cylinder Test - 20/40
4. Cylinder Rock - 20/40	4. Cylinder Rock - 20/40
5. Equalization - use of Risley prisms - 20/30 line	5. Equalization - Split Chart
6. Subjective - maximum plus for 2/3 of the 20/20 line	6. Subjective - maximum plus for 2/3 of the 20/20 line
7. Subjective best visual acuity - 20/15 line.	7. Subjective best visual acuity - 20/15 line
8. Acuities - OD, OS, OU	8. Acuities - OD, OS, OU
9. Acuities - OD, OS, OU with the binocular subjective and the conventional slide.	9. Suppressions and binocular instabilities - mixed letters
	10. Fixation disparity - central lock
	11. Stereopsis - with and without fixation disparity neutralized.

The recording form is shown in Table IV, listing each test's results in a side by side manner for easy comparison.

T.C – 12-8-72

REFRACTION ...IS

Conventional Refraction

OD –1.50 – 2.00 x 180
OS –1.50 – 2.25 x 180

7 Complex
20/30 Bl
OD ______
OS ______

Clockdial
OD ______ ______
OS ______ ______

Red-Green
OD –1.75
OS –1.50

JCC
OD –1.75 – 2.00 x 172 ±5°
OS –1.50 – 2.50 x 178 ±2.5°

20/30 Equ
OD –1.25
OS –1.00

SBVA
OD –1.50 – 2.00 x 172 ______
OS –1.25 – 2.50 x 178 ______

VA OD 20/15
OS 20/15
OU 20/15

Patient Comments

Examiner Comments

Binocular Refraction

OD –1.50 – 2.00 x 180
OS –1.50 – 2.25 x 180

7 Complex
20/30 Bl
OD ______ ______
OS ______

Clockdial
OD ______ ______
OS ______ ______

Red-Green
OD –1.50
OS –1.25

JCC
OD –1.50 – 2.00 x 172 ±5°
OS –1.25 – 2.50 x 178 ±5°

20/30 Equ
OD –1.00
OS –0.75

SBVA
OD –1.50 – 2.00 x 172 ______
OS –1.25 – 2.50 x 178 ______

OD 20/15
OS 20/15
OU 20/15

VABinoc Rx on Standard slide

OD 20/15
OS 20/15
OU 20/15

Patient Comments

Examiner Comments

1. Some crowding on mixed letters
2. No suppression
3. 1Δ eso. fixation disparity
4. Stereopsis = 4th line

Results

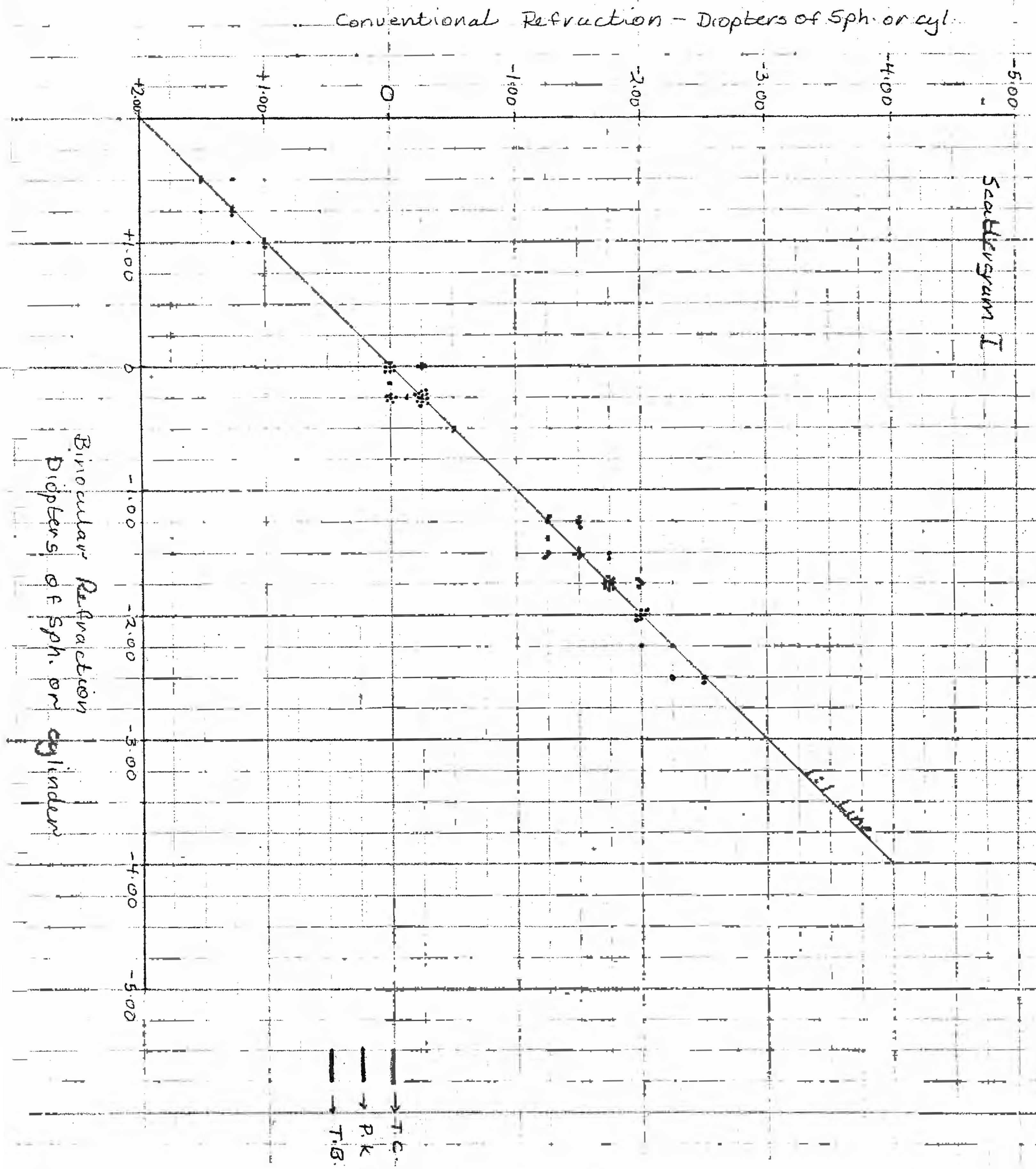
In order to obtain a measure of the reliability of each method of refraction - the conventional and the binocular method, three specific subjects were reexamined over four successive days. The testing procedures were exactly the same as performed during the main clinical investigation (see Table III).

Subject T.B. (22) was a 1.50 D myope with less than .50 D cylinder. Subject P.K. (27) was a 1.00 D hyperope with less than .50 D cylinder. Subject T.C. (24) was a compound myopic astigmatic of 2.00 D to 2.50 D.

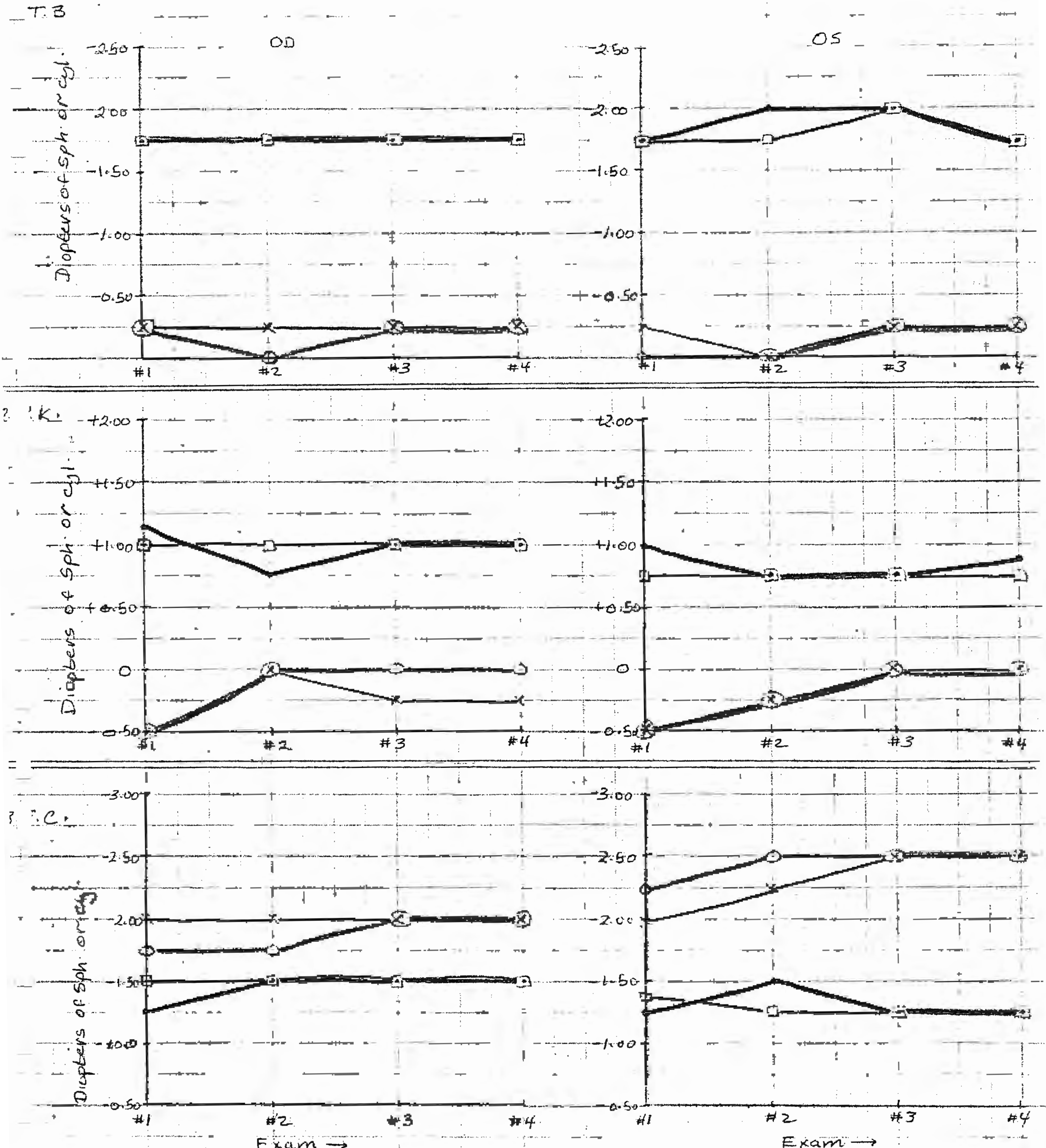
The daily variation in measurement of sphere and cylinder power was observed by fully repeating the examination routine on four successive days. The comparison of binocular and conventional methods for any given day yielded no more than 0.25 D difference between the two. This difference was considered to be a simple random measurement error. See scattergram I which plotted each subject's daily sphere and cylinder measurement.

The variation between successive days is plotted for each subject on graph I. The extreme variation was a .50 D cylinder measurement with subject P.K., which was not present after the first day's testing. For any given day of the four testing days no greater than a 0.25 D difference was noted.

As a result of repeating our measurements on three subjects over four successive days, we concluded that further evaluation of test-retest reliability with more subjects was not necessary.


Conventional Refraction - Diopters of Sph. or cyl.
+2.00
+1.00
0
-1.00
-2.00
-3.00
-4.00
-5.00
Scattergram I
Binocular Refraction
Diopters of Sph. or cylinder
1:1 line
T.C.
P.K
T.B.

Graph I — Graphs for Reliability Study - 3 Subjects - S.B.V.A.



•→ Sphere of Conventional Refraction
□→ Sphere of Binocular Refraction
X→ Cylinder of Conventional Refraction
O→ Cylinder of Binocular Refraction

Figure 1 displays a comparison of the red-green bichrome test for sphere at eighteen feet, under monocular and binocular conditions. Each frequency distribution represents the absolute difference between the right eye under monocular and binocular conditions and the left eye under monocular and binocular conditions. Monocular measurements under binocular conditions were achieved by the use of the vectographic slide with the eye being measured being the only eye able to see the letters. Statistically there is no significant difference between red-green sphere values. Inspection of the distribution suggests a slight tendency for the binocular red-green sphere values to show more plus. Further analysis shows that out of 126 eyes examined only 16 showed a difference greater than .25D and of these only two showed the difference in the same direction and magnitude. This indicates that the differences greater than .25D are probably random variations.

Figure 2, a frequency distribution of differences of cylinder power under monocular and binocular conditions, indicates no significant difference in cylinder power. Of the 63 right eyes and 63 left eyes examined, there were no differences in cylinder power in 43 right and 44 left eyes. Of the seven eyes showing a difference greater than .25D only one subject showed the difference in both eyes. This indicates that the differences are probably due to random test variations rather than systematic differences between monocular and binocular procedures. Of the seven eyes showing a difference in cylinder power greater than .25D, six showed an increase in cylinder power under binocular conditions and one under monocular conditions.

Figure 3, a frequency distribution of differences of cylinder axis under monocular and binocular conditions, indicates no significant difference in cylinder axis. Of 63 right eyes and 63 left eyes examined there were no differences in cylinder axis of 43 right eyes and 43 left eyes. Of the 126 eyes examined, 30 showed a change in axis greater than or equal to 5 degrees and of these 30 eyes only one showed a change of axis greater than the subject's just noticeable difference for axis. This subject had a 1.00D cylinder and changed ten degrees with a JND of 5°.

Figure 4, a frequency distribution of differences in maximum plus to subjective best visual acuity between the monocular and the binocular slide, indicates no significant difference in sphere values. The frequency distribution is a comparison of 63 right eyes sphere values with 38 eyes showing no differences and no eyes with a difference greater than .25D. The maximum plus to subjective best visual acuity on the vectographic slide was done on the letters that were not polarized and were therefore common to both eyes. The only difference between the two slides was the readability of the letters under the two conditions since the analyzer was not removed while using the vectographic slide.

Figure 5, a frequency distribution of differences in anisometropias as determined by a 20/30 equalization under split prism and vectographic techniques, indicates no significant difference in anisometropias. Of the 63 anisometropias taken, 38 showed no differences and only two showed a difference greater than .25D. Of the two showing a difference in anisometropias of .50D the vectographic anisometropia was more consistent with monocular and binocular red-green anisometropias.

Figure 6, displays the frequency distribution of the differences of red-green and 20/30 equalization anisometropias under standard and binocular slide conditions. Inspection indicates that the standard slide shows a tendency to be more internally consistent. There was no difference in anisometropias in 39 of 63 subjects under standard slide conditions and there was no difference in 24 of 63 subjects under binocular slide conditions. The binocular slide has fewer variations greater than .25D. The binocular slide had only three subjects with a variation greater than .25D, while the standard slide had six subjects with a variation of anisometropias greater than .25D. A larger sample would be necessary to determine if the differences are other than chance variation.

Figure 7, a frequency distribution of differences in visual acuity between the binocular slide and the standard slide, indicates that there is a significant difference in visual acuity in approximately 30% of the eyes examined. There was a difference of one-half line (3 letters) in 12 out of 63 right eyes and 12 out of 63 left eyes examined. There was a difference of one line (6 letters) in eight out of 63 right eyes and nine out of 63 left eyes. In no case was the acuity better on the binocular slide, but there were 43 right eyes and 42 left eyes that had no difference in visual acuity. Many subjects reported greater difficulty calling the letters on the binocular slide as opposed to the monocular slide even though they called all the letters on both.

The following is an analysis of response to the vectographic slide to detect and where applicable measure partial or complete suppression, binocular instability, stereopsis, and fixation disparity.

Of the 63 subjects examined there were no complete suppressions, but there were eight partial suppressions that responded. Partial suppression responses indicate that some or all of the letters corresponding to one eye's stimulus would periodically fade out. This test was conducted on the smallest line of mixed letters. Of the eight partial suppressions, six showed a fixation disparity and two had no fixation disparity.

Binocular instability response on the 20/40 mixed row of letters occurred when the subject reported crowding, "swimming" misalignment vertically, separation or near-far distance change of the letters. Seventeen subjects reported a binocular instability response. Of the 17 instabilities, ten manifested a fixation disparity and seven showed no fixation disparity.

Fixation disparity responses were detected and neutralized utilizing the central fusion lock target. Of the 63 subjects, 17 showed a fixation disparity. There were nine eso disparities of which three were one prism diopter, four were equal to two prism diopters, and two were equal to four prism diopters. There were six exo disparities of which five were equal to one prism diopter and one was equal to three prism diopters. There were two vertical disparities. One was equal to one prism diopter and the other was six prism diopters (equal to the amount of vertical prism in present Rx).

All subjects had all four lines of stereopsis. After the stereopsis was tested the prism equal to the amount of the fixation disparity was introduced and the subjects were aksed if there was any change in stereopsis. Of the 17 disparities neutralized, five subjects indicated that the prism enhanced the stereopsis, i.e. subjective depth was increased.

The examiners did not retest the stereopsis by removing the neutralizing prisms, a point worthy of consideration for future investigators.

Discussion of Results

Our study has shown no significant quantitative differences between conventional and binocular subjective refraction at 18' with respect to magnitude of cylinder power, cylinder axis, red-green sphere, 20/30 equalization for anisometropias, and maximum plus to best subjective visual acuity. A significant difference in monocular visual acuities was demonstrated. According to the work of Richards[10] and Ludvigh[11] the decrease in contrast from .93 to .68 cannot fully account for the decrement in visual acuity found in 30% of our subjects. Other factors not controlled in our study that may effect visual acuity include: surround luminance (which was the major cause of the decrease in contrast), the effect of a blank field presented to the eye opposite to the eye being measured, and different perceptibility of the test letters.

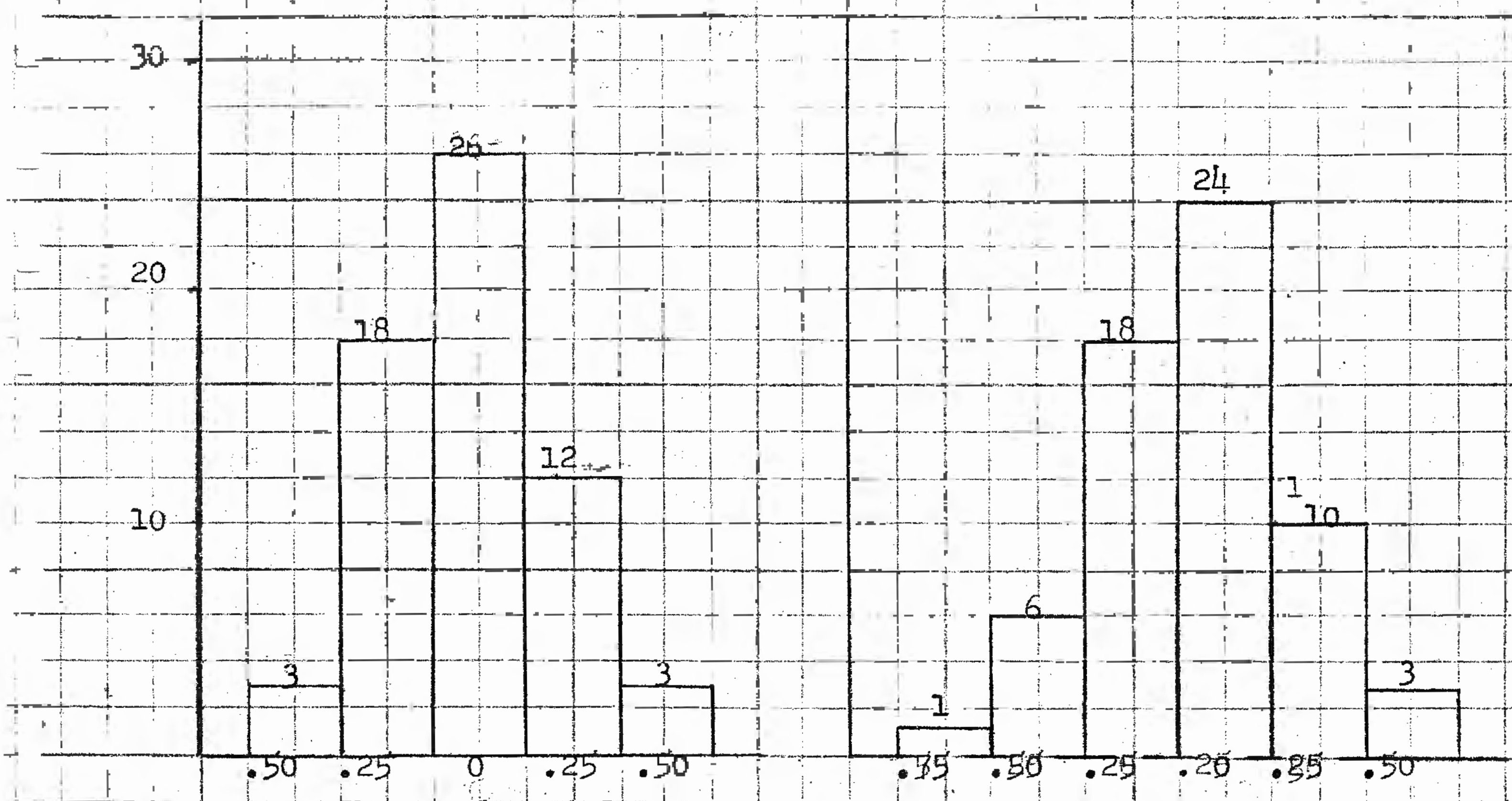
Our study has also shown that the vectographic slide is very useful in detecting partial suppressions, neutralization of fixation disparities, detecting binocular instabilities and for testing stereopsis. The vectographic approach to refraction is thus a very useful clinical tool

Suggestions for Future Studies

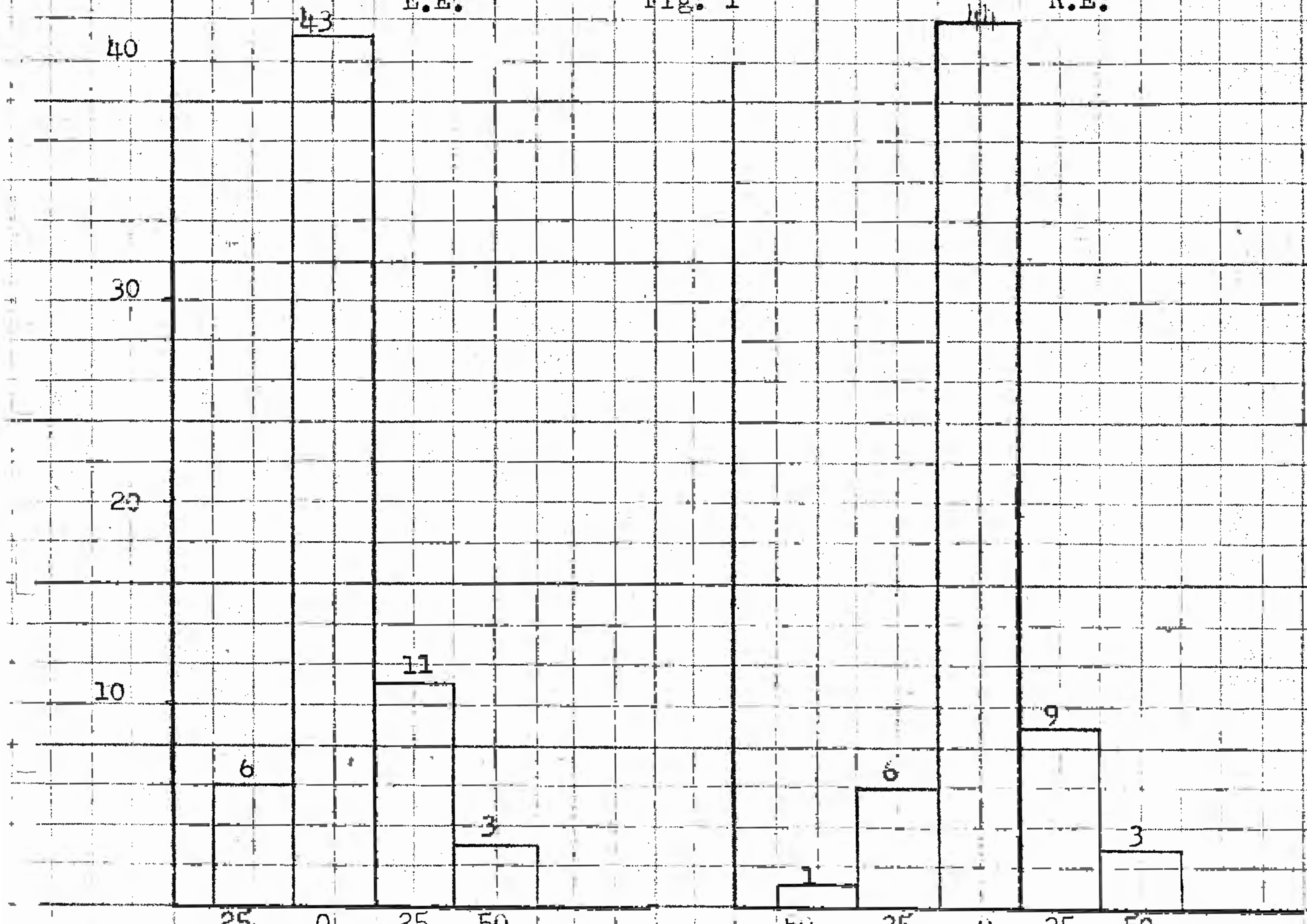
Further study is needed to factor out the effects of the various stimulus variables not controlled in our study to determine the exact effect of each on visual acuity. We suggest that further study of changes in cylinder axis under binocular conditions be done on subjects with a significant amount of cylinder power who are more sensitive to small changes in axis. With respect to the physical setup of the refracting room, a non-depolarizing screen should be used, the patient should be seated at the angle of reflection and the room illumination should be at a minimum.

Summary

Our study has shown that binocular refraction is reliable and that there is no significant difference in distance refraction when compared to the standard monocular methods. We have also shown that there is a difference in visual acuity on the vectographic slide and that contrast was a major factor. The study indicates that the A.O. slide is useful in detecting binocular instabilities, neutralizing fixation disparities and testing stereopsis.

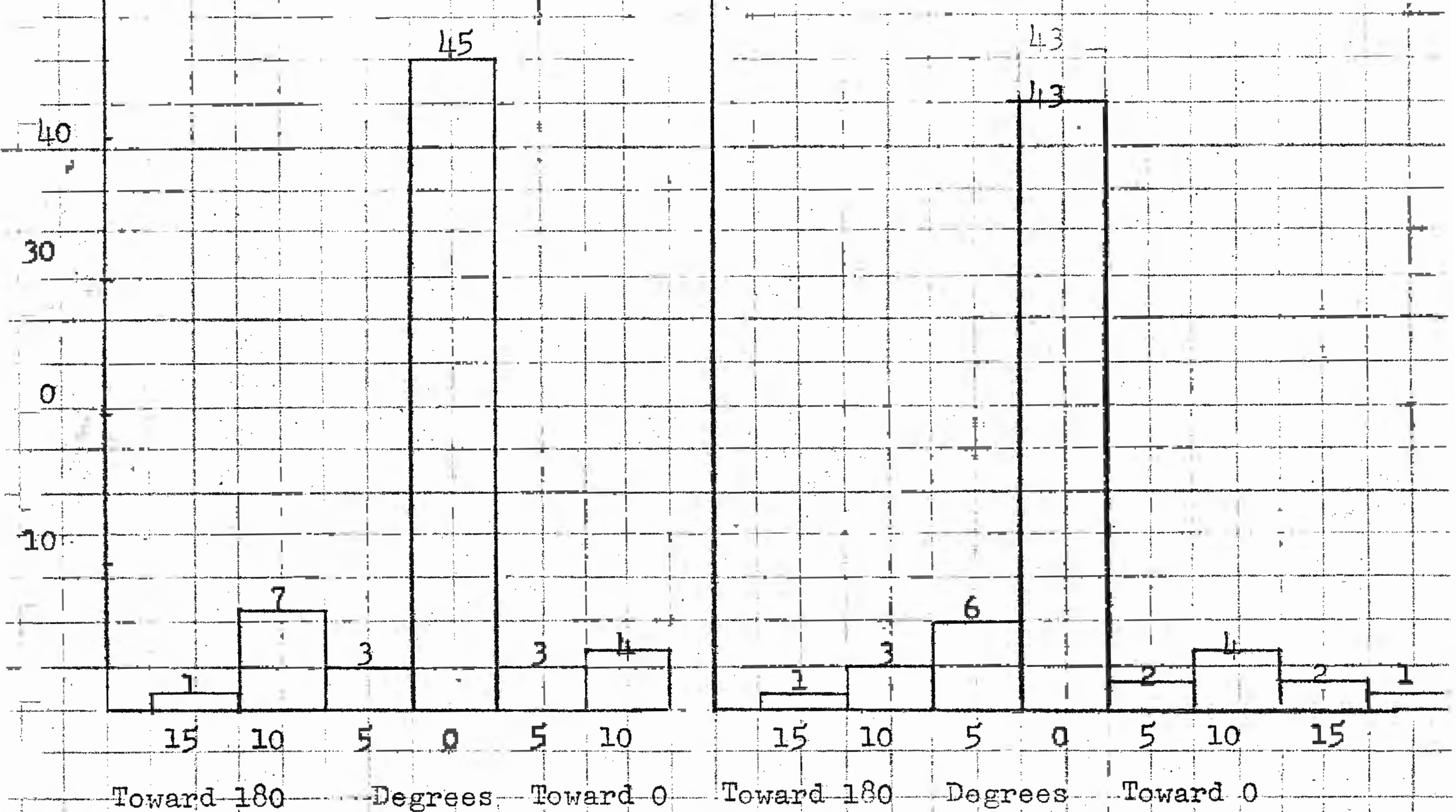


L.E. Fig. 1 R.E.



L.E. Fig. 2 R.E.

L.E. Fig. 3 R.E.



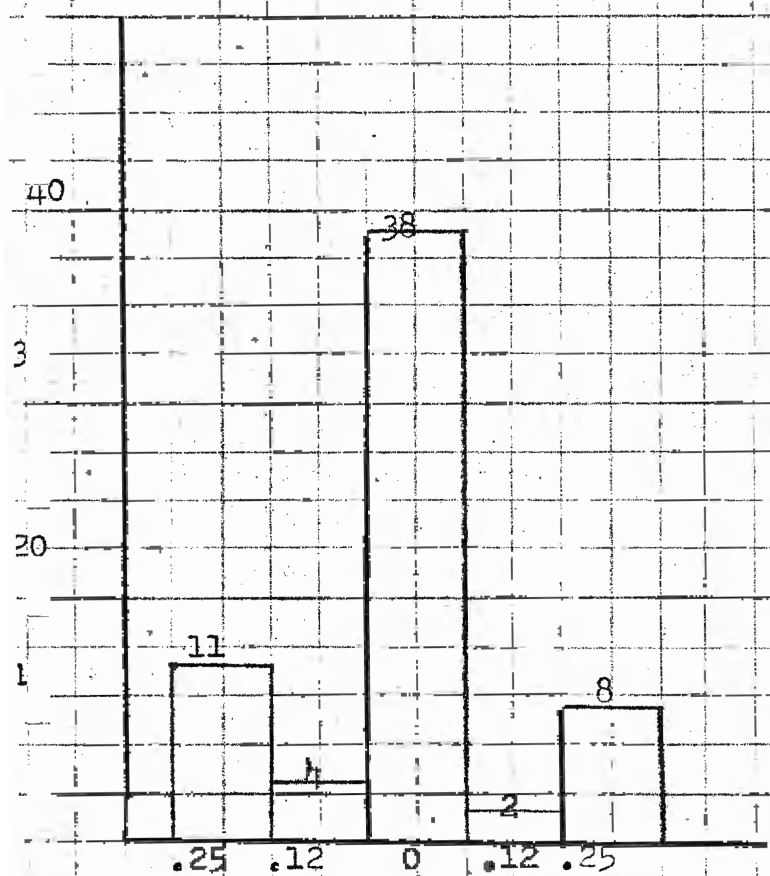


Fig. 4

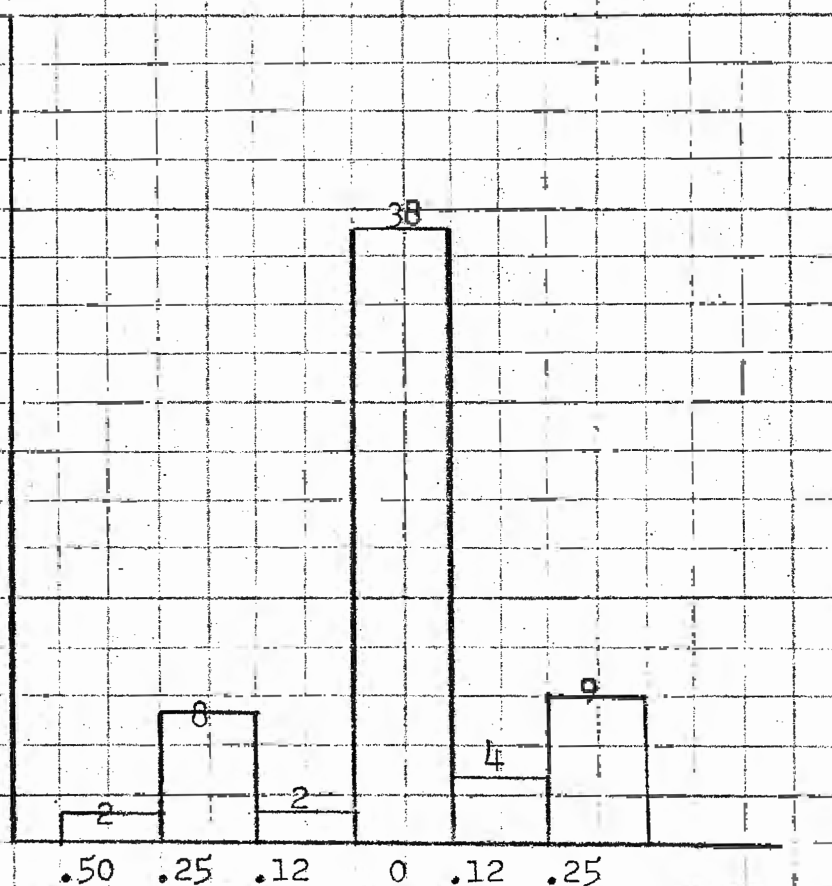
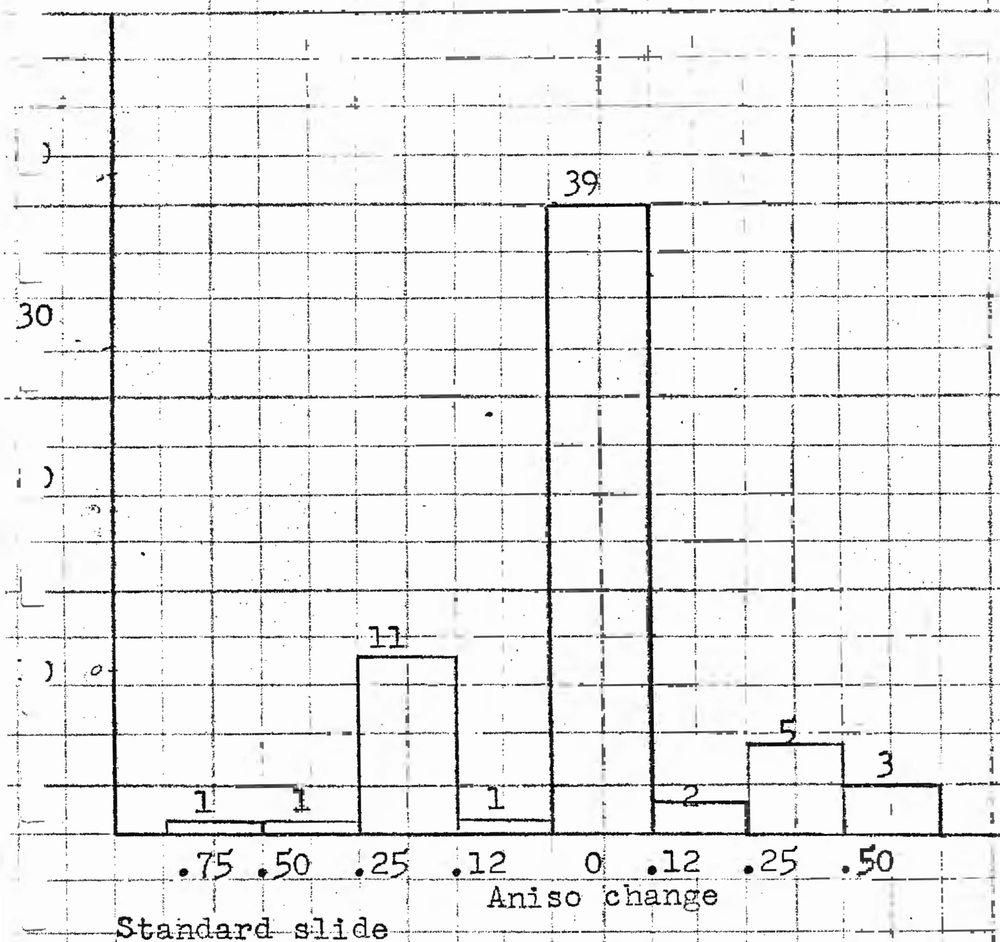


Fig. 5


30
39
11
5
3
1
1
1
2
.75 .50 .25 .12 0 .12 .25 .50
Aniso change
Standard slide

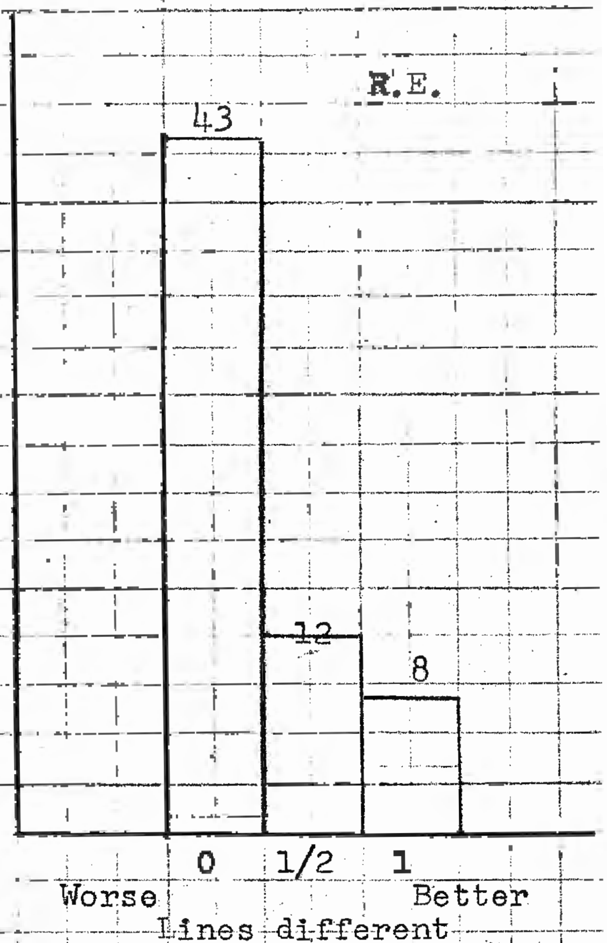
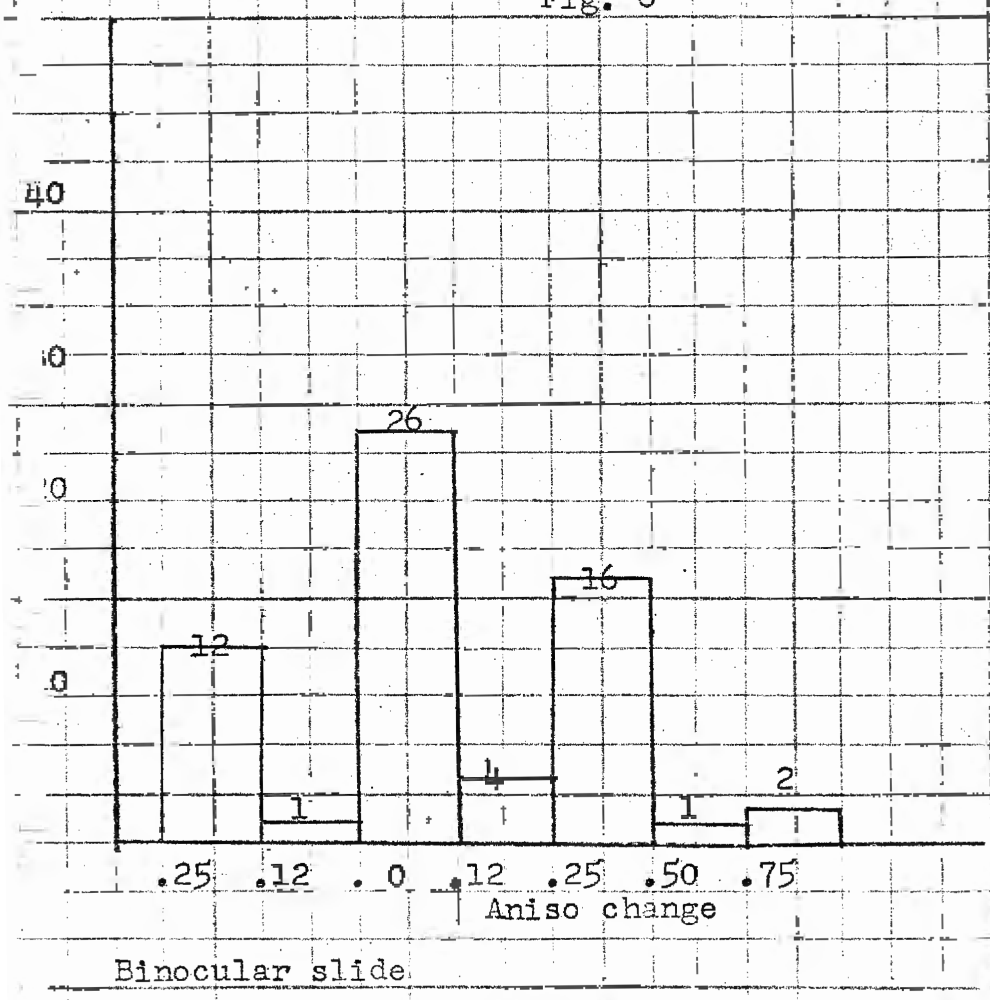
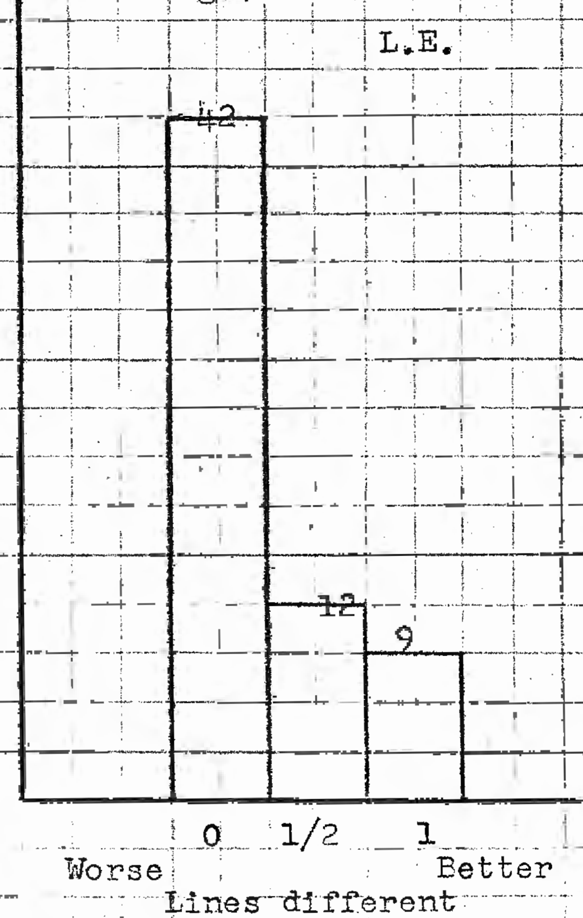

R.E.
43
12
8
0 1/2 1
Worse
Better
Lines different

Fig. 6

Fig. 7


40
26
16
12
1
4
1
2
.25 .12 . 0 .12 .25 .50 .75
Aniso change
Binocular slide


L.E.
42
12
9
0 1/2 1
Worse
Better
Lines different

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